THE JOURNAL OF
PROSTHETIC
DENTISTRY

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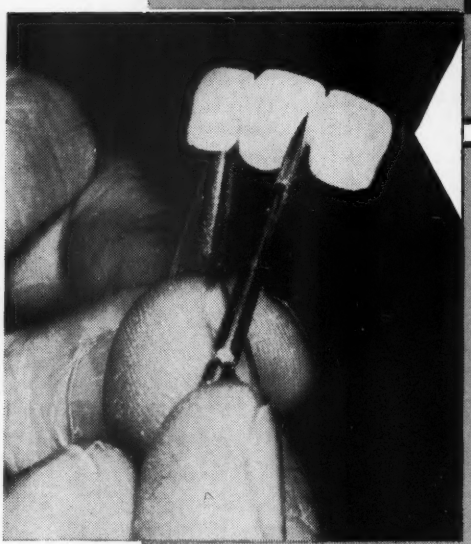

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FIXED PARTIAL DENTURES

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High speeds are those from 100,000 to 200,000 r.p.m. Rotational speeds beyond this are classed as super speeds. Definite advantages and disadvantages are inherent with each class of instruments. Safeguards for both the patient and the dentist must be used with these instruments. Certain operations can be done best with low-speed instruments.

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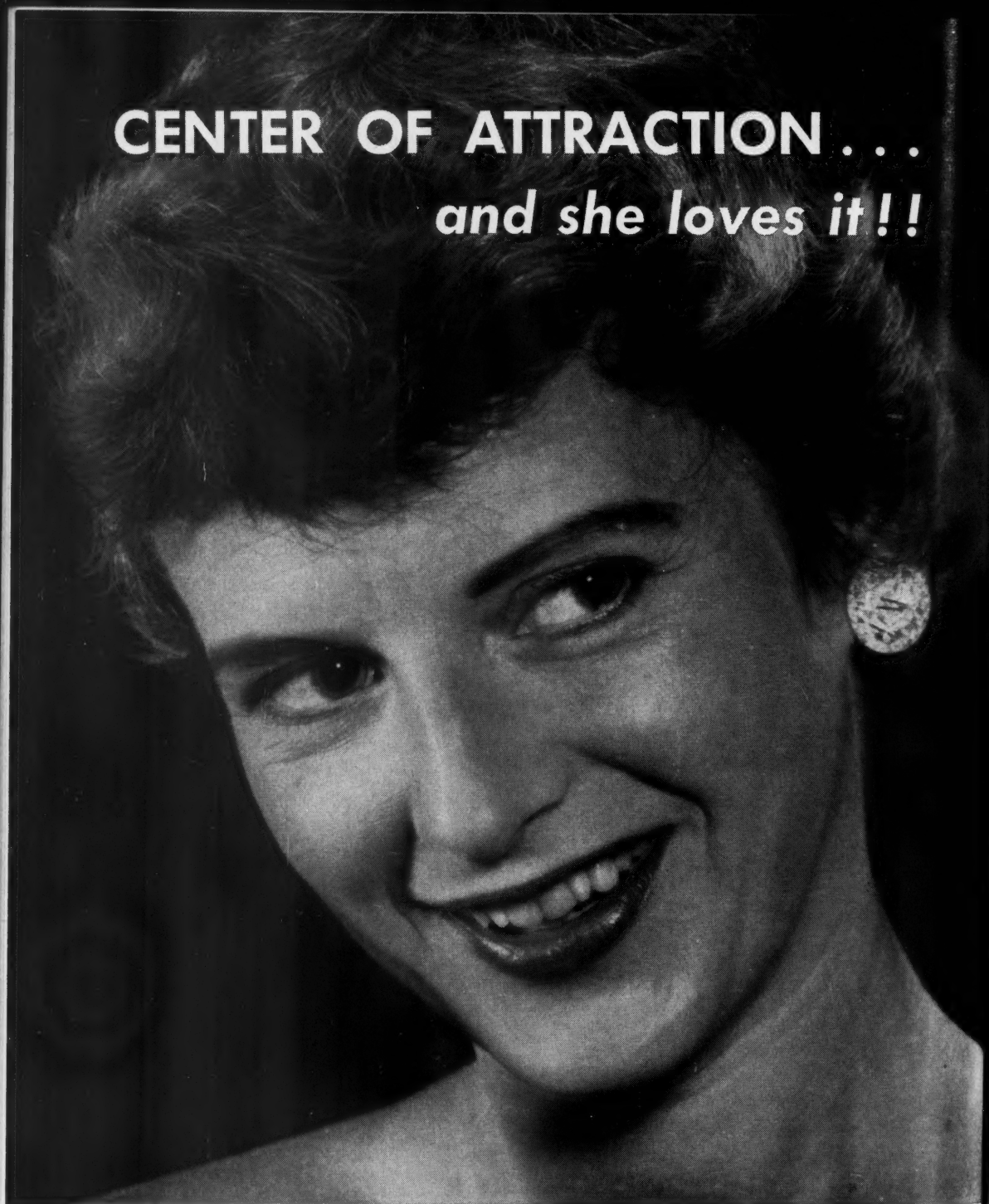

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Changes in Pulp and Periodontal Tissues of Teeth Subjected to Crown Prosthesis.
H. M. Dávila Alonso, D.D.S., M.S.D., Grant Van Huysen, D.D.S., and John F. Johnston, D.D.S., San Juan, Puerto Rico, and Indianapolis, Ind. **350**

Various handpiece speeds were used to prepare human and dog teeth for crowns, and crowns were made with heavy occlusal contact as well as without occlusal contact. The tissues involved were studied histologically, and a remarkable tolerance and adaptability were found, provided normal clinical care was used.

Periodontal Therapy by Root Resection.
Ralph S. Lloyd, B.S., D.D.S., and Paul N. Baer, B.A., D.D.S., Bethesda, Md. **362**

The hopelessly unsupported root of a molar tooth is removed to eliminate the periodontal pocket, and a restoration is placed on the remaining half of the clinical crown. Then, this restoration is splinted to another tooth.

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Nathan Allen Shore, D.D.S., New York, N. Y. **366**

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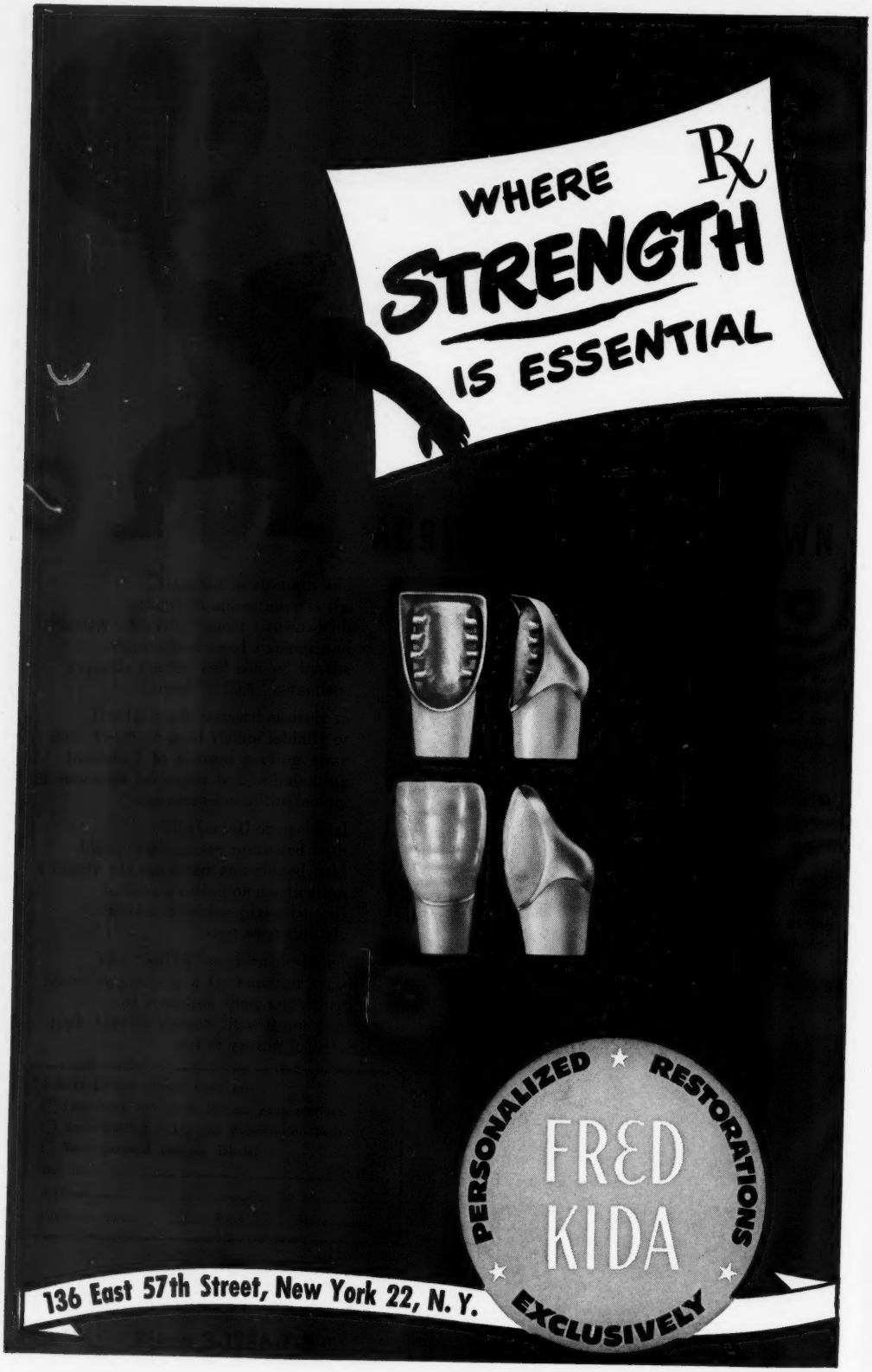
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THROUGH THE EYES OF THE EDITOR

Dayton Dunbar Krajicek discusses the creation of satisfactory esthetic appearance of dentures, and he recommends that natural teeth be copied in order to achieve the desired results. He points out the factors which must be considered in the selection and arrangement of teeth. His system of planned irregularities, if it is properly applied, will avoid the appearance of artificiality.

Victor H. Sears discusses the terminology regarding jaw relations, jaw relation records, and tooth occlusions. He describes his philosophy of terminology and suggests a system of terms which separates the various components of jaw relations. This concept of terminology is worthy of further study. It may lead to a better understanding of jaw relations and to better communication regarding them.

Don N. Brotman discusses various concepts of mandibular movement and occlusions during function. He points out those concepts with which he disagrees and describes his interpretation of jaw function. He considers the "closing" movement as *the* functional movement. This is interesting because in reality *any* movement made by the mandible is functional from the standpoint of physiology. He emphasizes the importance of the transverse and vertical axes of movement and of the neuromuscular system in protecting teeth from trauma when deflective occlusal contacts exist. He believes that Bennett's observations were incorrectly interpreted and that the condyle paths are of little value because they are recorded with opening rather than closing movements. These controversial problems are worthy of further study.

Robert V. Winders discusses the triad of occlusion, musculature, and the temporomandibular joints as it relates to the health of the parts and the whole. He emphasizes the importance of neuroanatomic considerations. That many patients can learn to avoid disturbing deflective occlusal contacts cannot be denied. Other patients do not seem to be able to compensate for a lack of coordination between the components of the triad. This is especially true when complete dentures are being worn. The lack of proprioceptive guidance from periodontal ligaments can account for the difference.

Ernest R. Granger considers an articulator as a mechanical instrument that is designed to reproduce the movements and positions of the mandible in relation to the maxillae. He believes that the more accurately the relationship between the temporomandibular joints and the joints of the instrument is established, the simpler becomes the problem of making dental restorations to fit each other in the mouth the same as they do on the articulator. He feels that the "simplified" instruments require more skill on the part of the dentist than the more complicated intsruments. There is logic in this concept. However, two other essential factors are involved. Regardless of the accuracy of the articulator as a mechanical device, the accuracy of the records made from the patient will determine the accuracy of its

adjustment. Second, the dentist or technician using any articulator must have an accurate concept of jaw movement and occlusion, as well as knowledge of the limitations of the instrument, in order to use it successfully. He emphasizes the importance of a variable intercondylar distance. The lack of this adjustment on most articulators in daily use is probably their greatest deficiency. The situation causing the greatest difficulty for patients, however, is the failure to adjust and use these articulators in the way they should be used in order to obtain the maximum benefit from them. Too often, even the minimum of an arbitrary face-bow record and one eccentric interocclusal record is not made.

Ulf Posselt and Bert Skytting report their studies of condyle path inclinations to determine the relative accuracy of graphic and static (intraoral wax) records. The graphic method used was similar to that suggested by Gysi, and it showed about twice the error of the static record. The probable cause of the larger error by the graphic method is one of interpretation of the record for adjustment on the instrument. It would be interesting to see a comparison of the results with intraoral wax and intraoral plaster records.

Raymond Cohen urges the practical application of basic sciences in recording jaw relation records. He emphasizes the importance of centric relation and uses the hinge axis registration to assist in its location He suggests the use of a "hinge axis trainer" to assist the patient to learn how to perform the hinge mandibular movement. He uses an interocclusal wax record in these registrations. There will be some who believe that wax used for this purpose may introduce errors in the centric relation record. There may be some question about the desirability of using external force on the mandible *at the time* the registration is made. If the patient can learn to make the hinge mandibular movement, the record of centric relation might be better made by the patient's own muscle power.

T. S. Malson describes his method of recording the vertical dimension. He uses a small cone of very soft wax to make the record and depends upon the swallowing act to mold the wax to the proper level. He emphasizes the importance of the movement of the thyroid cartilage (Adam's apple) as an indication of a correctly established vertical dimension of occlusion.

Romie H. Miller finds it necessary and desirable to use posterior teeth of different sizes in the same denture. He suggests that the manufacturers supply posterior teeth with *long* bicuspids and *short* molars. Teeth carded in this manner would be helpful in many situations.

Joseph S. Landa continues his discussion of the causes and treatments for denture difficulties and irritations. He points out bruxism, the use of excessive muscular force by the patient, and various malocclusions as causes of traumatic injury. His suggested tests and treatments should eliminate much of this type of trouble if they are properly applied.

Lester E. Rosenthal, Robert Boyer, Jules V. Lane, and Stanley L. Lane describe the surgical and prosthodontic techniques for supplying dentures for patients after partial glossectomies.

Robert E. Herlands, Austin H. Kutscher, John J. Lucca, Edward V. Zegarelli, James L. Mercadante, and Norman Roland report their observations on effectiveness of a new denture adhesive. They emphasize the fact that denture adhesives should *not* be used with well-fitting dentures. There is question that adhesives should be used, except in unusual situations, such as in some surgical prostheses. If a denture "fits," there is no space for an adhesive, and it is conceivable that the additional bulk could promote the resorption of bone in these situations. If the denture does *not* fit, the denture should be corrected.

Jerome M. Schweitzer describes an appliance for improving the appearance of mouths that have undergone extensive periodontal treatment after having lost considerable bone. The appliance will also promote oral hygiene, provided it and the teeth receive proper cleaning by the patient. A failure to do this could invite dental caries, but patients who have had this type of treatment are likely to realize their responsibilities. The available materials made the construction of the masks quite simple.

John F. Johnston, Donald M. Cunningham, and Robert G. Bogan discuss the relative responsibilities of the patient and the dentist in the preservation of the patient's residual ridges. The dentist must be sure his treatment is correct and the patient must have sufficient

faith in the dentist to permit him to provide the correct treatment. The treatment involves an adequate diagnosis and treatment plan and recognition of definite factors which will tend to prevent further residual ridge destruction under removable partial dentures.

Harry Kazis and Albert J. Kazis discuss complete oral rehabilitation by means of fixed partial prosthodontics. They depend upon the physiologic rest position as the starting point for the establishment of the occlusion. They support the contention that the physiologic rest position is constant throughout life and consider the vertical dimension of occlusion to be the variable. This variation can be observed in variations in the interocclusal distance. They emphasize the importance of other factors such as the crown-to-root ratio as influencing their development of the reconstructed occlusion. It seems logical to consider all factors in their proper perspective, if the reconstruction is to have lasting value. They think of their concept as being dynamic instead of static. However, any dynamic relationship consists of innumerable static relationships just as a line consists of innumerable points.

Charles E. Stuart and Harvey Stallard discuss the principles involved in restoring occlusion to natural teeth. They recognize a difference in the requirements for balanced occlusion in natural dentitions and artificial dentures. They suggest that the lingual inclines of the upper cuspids should be the keys to the formation of the cuspal forms of the posterior teeth. This concept seems to be gaining support among many authors. In this discussion, the many interrelated factors are discussed in a logical manner.

Alexander Leff discusses the use of high rotational speeds in dental handpieces for making full-coverage preparations. He points out the advantages and disadvantages of using the high-speed instruments, and these should guide the choice of the speeds to be used and the precautions to be taken. A water, instead of air and water, stream is recommended as a coolant.

Douglas M. Lyon, George T. Cowger, Felix F. Woycheshin, and Charlotte B. Miller report their tests of materials used for porcelain baked on metal restorations. The results indicate that the type of metal and the type of of porcelain must be correlated for the best results. Further research will improve these materials and the techniques for their use so they will have the desirable characteristics needed.

William H. Bert Hagen describes his technique for making a combination gold and porcelain crown. The method might be considered as a porcelain inlay in a gold crown. There seem to be many advantages in this technique, even though it is not as simple as some others.

Norman L. Schwartz describes his technique for flasking and processing acrylic resin veneers on large fixed restorations and complete arch splints. The use of cores in the flasking procedures permits the accurate placement of the colors in the veneers and trial packing without danger of distortion.

Joseph Rubinstein describes his technique for the preparation of cavities for amalgam restorations. His specifications for the prepared cavity should overcome the failures from improper preparations. The retentive grooves he suggests might require extra care during the insertion of the amalgam.

Joseph F. Volker discusses the causes of dental caries and reports his research into the effect of carbohydrate retention on tooth surfaces. He found several variables which may account for some of the conflicting reports which have been made. His evidence indicates that certain microorganisms must be present if carbohydrates are to act as caries accelerators and that there is a definite relationship between the length of time the carbohydrates are in contact with the tooth surfaces and the caries activity.

H. M. Dávila Alonso, Grant Van Huysen, and John F. Johnston report their studies of the effect of the preparation of teeth for crowns and occlusion on the pulp and periodontal tissues. They used different tooth-cutting instruments on human and dog teeth. The results seem to indicate that handpiece speeds from 6,000 to 200,000 r.p.m., when used in commonly accepted clinical practice, do not endanger the pulp tissue unless it is nearly exposed (less than 0.5 mm. of dentin between the preparation and the pulp). Their tests with the restored teeth in heavy occlusion and with a slight lack of occlusion also show a remarkable adaptability on the part of periodontal tissues. It should be noted, however, that the subjects were relatively young. It is

possible that the temporary disturbances would have been permanent in older subjects. There can be no harm in taking all possible care to protect the pulp and to establish a harmonious occlusion.

Ralph S. Lloyd and Paul N. Baer suggest root resection in conjunction with periodontal treatment as a means for saving natural teeth in some critical situations. This might be considered as radical treatment, but it can be useful where it is indicated.

Nathan Allen Shore discusses the symptoms and treatment of temporomandibular joint dysfunctions. He attributes 90 per cent of these to "abnormal dental occlusions." His recommended treatment involves the use of drugs coordinated with strictly dental treatment. It seems logical to eliminate pain before dependable records could be made for reconstructing the occlusion.

Herbert D. Ayers, Jr., Ralph W. Phillips, Alex Dell, and Richard W. Henry report their tests of the accuracy of reproduction by elastic impression materials. Ten impression materials and three cast materials were studied. Comparisons are made between the different classes of materials. Their results show the alginates to be less accurate than other types of impression materials, but they found the greater error to be from the cast materials. Failure to reproduce surface detail was the most notable error.

Robert W. Shippee reports his studies of the accuracy of impressions made with elastic impression materials. Both laboratory and clinical observations and measurements were made. The results indicate that there are significant variations between the accuracy of different materials and that care must be used in the manipulation of all of them.

W. W. Wainwright describes the procedures for adding safety features to dental x-ray machines. These will provide additional protection from radiation and are inexpensive to apply.

Robert G. Vig discusses his reactions to prosthetic dental literature, but it is likely that similar criticisms could be leveled at scientific articles in many fields. Unfortunately, the problems he raises do not have a simple solution. If everyone was to wait until there could be no possible error in the concepts he was writing about, no one would write. Not all of the facts are known, so any article must be considered as a progress report based upon the experiences of the author to the time he writes the article. The reader must evaluate any article on the basis of his own knowledge and experience. The author should be conservative in his claims about the absolute accuracy of his concepts. His concepts must remain largely as opinions, even though they appear to be facts in view of the information available to him at the time he writes his article. However, the author is obligated to write so clearly that, right or wrong, his concept is understood.

—Carl O. Boucher

COMPLETE DENTURES

NATURAL APPEARANCE FOR THE INDIVIDUAL DENTURE PATIENT

DAYTON DUNBAR KRAJICEK, D.D.S.*
Wadsworth, Kan.

THE APPEARANCE PHASE of complete denture construction occupies a role of increasing importance to both the general practitioner and the prosthodontist. The interest in this subject has been so universal that this area has been termed the period of esthetic renaissance in dentistry. This dramatic revival of esthetics can be credited to the following factors:

The Development of Materials.—Through scientific research, the acrylic resins were perfected for use by the dental profession. Vulcanite has been replaced as a base material, and plastic teeth have been used for approximately 15 years. However, esthetics implies considerably more than the use of certain materials or the tinting of the denture base and the use of prominent carvings.[1]

The Use of Guiding Principles.—The efforts of innumerable dentists have promoted and encouraged the application of practical artistic principles to the appearance phase of complete denture construction. General rules and technical procedures based on individual patient needs were formulated to serve as guideposts in creating pleasing yet natural-appearing restorations. Some theories, such as that of the tooth-ridge relationship, are being discarded in the light of current scientific analysis and study. While the dental artist is still encouraged to develop an esthetic sense to interpret individual esthetic requirements, he now has the advantage of artistic guides which may be used in devising his anterior compositions.

Psychologic Impact.—Esthetics has become a more convenient and practical goal, and the dental profession has become attracted to its clinical application. The psychologic importance is not fully appreciated even now, but continued interest is being maintained on the basis of professional pride and the challenging possibilities which this modern artistic system presents.

REVIEW OF ESTHETIC PROGRESS

There is no such thing as perfection in the field of dental esthetics. This statement remains as true today as it has been in the past. There is no excuse for the

Read before the American Denture Society, Dallas, Texas.
*Chief, Dental Service, Veterans Administration Consolidated Center.

amateurish denture which must be appropriately designated as "false" from the standpoint of appearance. No denture has been constructed, however, which will fool all the people all of the time. Unlimited opportunities for improvement continue to exist.

The slow development of denture art is partially responsible for the mistaken opinion that esthetics in dentistry is new. Frush and Fisher[2] stated, "Except for the term 'dentogenic,' there is really nothing new in the field of prosthetic esthetics which has not, at one time or another, been written about, talked about, or at least thought about."

There is evidence that our present standards have continued with little change for the past 50 years. Campbell* said, "The most important element in the creation of artificial teeth which calls for development and challenges dental genius is the artistic side. It is safe to say that 90 per cent of the complete dentures worn by patients are inartistic atrocities. They are either too white, too small, too precise, or too brazen in their display and generally lack harmonic agreement with the individual characteristics of the patient. The most significant function of man-made teeth is their esthetic appearance. The candidate for complete dentures demands first, comfort, then appearance, and last of all, efficiency. This is perfectly natural, since one does not go from Nature's fine masticating mechanism to the edentulous state immediately. On the contrary, the path of this process is marked by milestones of gold and porcelain until, at length, the patient has become accustomed to punching an occasional hole in the bolus of food and swallowing it with a gulp." This was spoken 30 years ago. Modern progress must truly be the result of these timeless concepts which have been converted into usable esthetic principles and practical artistic technics.

The theory of complete artistic freedom from all binding rules was the first to be challenged. The challenge was logical since this is a rule of pure art and not applicable to dental art. The dentist is not creating a new artistic product when he constructs a denture. He is rebuilding a face in conformance with Nature's plan by replacing a visible and functional lost part. Since the artificial substitute must not direct attention to but conform with the rest of the face, certain rules can be used as guides, but they must complement and not dominate a developed artistic sense. Complete dependence upon rigid rules can only lead to undesirable stereotyped effects. This detracts from the qualities of individuality and naturalness. These guides must not be considered as binding rules but practical mental expressions developed from a study of the human face in which the natural dentition is present. Even with these helpful principles, esthetic problems still cannot be reduced to a given formula as easily as can the mechanical procedures of function.[3]

DENTOFACIAL OBJECTIVES

The primary aim in the appearance phase of complete denture construction must be that of gaining realism by providing a natural-appearing substitute for the lost dentition. This signifies naturalness in the appearance and function of the face

*Dayton Dunbar Campbell: Address before the Colorado State Dental Association, 1930.

and lips using natural tooth forms and shades, as well as copying anterior compositions from appropriate natural dentitions. Eversull* has stated our esthetic objective, "We have but to copy not create."

Appearance is always an individual factor for both the patient and the dentist. To attempt to analyze or treat appearance from the vague approach of generalities is extremely hazardous. Esthetics may conflict violently with our professional interpretation of naturalness for the individual, because from the patient's standpoint appearance is predominantly an emotional reaction. The dentist should never *force* a patient to agree to the arrangement of the teeth on a denture which the dentist believes is the epitome of perfection. Actually, the patient's undeveloped esthetic sense may demand a symmetrically beautiful product with small white teeth and no break in their alignment. But neither should the dentist deny the patient every opportunity to know and see what could be accomplished by the construction of a denture which possesses individuality and defies detection as being artificial.

There is a regretable tendency among dentists to discredit and minimize the importance of appearance to institutionalized people. The consensus is that the male veterans comprising this elderly age group are interested solely in function. Some patients may profess an indifference to appearance, fearing that it is a display of unmanly weakness. Others have definite, deeply rooted, preconceived ideas of what they desire. These ideas are based either upon dentures they have seen or past denture experiences. Because unesthetic dentures are more numerous than those which attempt to copy Nature's creations, it is not difficult to see how this idea is established.[4] Education regarding the advantages of natural-appearing dentures is essential. While the desires and needs of edentulous people are never uniform, neither are they akin to special age groups or social environments. Individuals will not be standardized.

The professional or intellectual approach to the subject is in contrast to the emotional aspect of denture appearance. Ideally, the intellect (the mental powers by which knowledge is acquired, retained, and extended) should be the influencing factor used by the dentist in accomplishing the individual objectives of appearance. A collection of casts, photographs, and color slides made from patients with pleasing natural teeth can be studied. In addition, mental images of natural dentitions of middle-aged and elderly patients should be retained and copied. This suggests seeing with the mind. To merely look with the eyes is to be mentally blinded to the oral and facial compositions of Nature. We should constantly strive to condition our artistic mental capacities to see beyond the carious lesions and calcareous deposits, and to scrutinize natural dentitions with the inquisitiveness of an artist studying a landscape which he is about to paint. This is the intellectual approach to appearance. It can be demonstrated and taught, and it is fundamentally sound. Yet, if the profession universally subscribed to this single esthetic concept, there would still be disagreement. Individual human emotions cannot be severed from the power of thought.

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*H. Eversull: Lecture before the University of Kansas City, School of Dentistry, Alumni Meeting, March, 1957.

If we routinely select a natural denture composition on an individual basis and harmonize it with the features of the face as we see them, however, our prosthetic restoration will approach the desired goal of patient individuality. Further, it will project the illusion of having gone through the years with the face without perpetuating any of Nature's inharmonious errors. Dentofacial objectives can be satisfactorily fulfilled by this method. Eversull summarized this concept by saying, "It is far better to have teeth that look like someone—than no one at all." Only when patients unwisely demand perfectly arranged teeth can this objective be ignored.

FUNCTION VERSUS APPEARANCE

Too frequently the dentist narrows his appreciation of patient needs to function alone and excludes the appearance factor. In these cases, the placement and arrangement of artificial teeth is guided solely by mechanical principles. Ideally, the elements of mechanics, phonetics, and esthetics should be carefully evaluated and then discreetly incorporated into the treatment plan to provide maximum patient comfort. Although some authors indicate that the objectives of function and esthetics are inseparable, this does not seem to be accepted generally. The concept that appearance and function represent major compromises in complete denture construction still predominates.

Surprisingly, patients whose dentures have the poorest appearance are often the loudest in their praise of their ability to use them. These patients may be proud of their success in biting an apple or chewing corn on the cob. These are acrobatic feats accidentally discovered and developed by the patient and have more to do with the application of physical laws in the *use* of the teeth than with the teeth themselves. Patient reports such as these may sound impressive; however, most of these people have an exaggerated conception of their masticatory efficiency with dentures. Give such a patient a bite of celery or dried beef, and after 10 minutes he will have severed scarcely a fiber. Although esthetics is sacrificed routinely on the altar of function, the mechanical efficiency of artificial restorations is not unfavorably hampered when certain guiding rules of appearance are intelligently incorporated into the edentulous treatment plan.

APPLICATION OF GUIDING PRINCIPLES

Diagnosis and Treatment Planning.—Consideration of appearance in denture construction is not isolated to one appointment. It is an integral part of diagnosis, since this visit establishes the wants and needs of the patient. A careful evaluation of the mental attitude of the patient pays rewarding dividends, because there are always preconceived hopes and aspirations which influence the success of the prosthetic undertaking. A determination of these desires before starting the treatment is mandatory, for there may be a vast difference between what the patient hopes to receive and what can be expected. Patients vary in their emotional responses regarding esthetics from an obvious attitude of indifference to the demanding state where the entire life seems to center around the appearance of the oral cavity. Patients at both extremes require explanation and precise education. In the final

analysis, the emotional feeling of the patient in cooperation with the artistry of the dentist determines the esthetic result. This mental harmony between patient and dentist must exist or failure is inevitable.

Impressions.—The length and thickness of all denture borders are important in establishing pleasing facial contours. The natural appearance of the lips in relationship to the base of the nose is of prime significance. Improperly formed labial denture borders which produce tenseness and extreme fullness of the lips are detrimental to normal facial expression. Denture borders may require variations in the length and fullness, from one side to the other, to produce an acceptable nose and lip contour because of the lack of symmetry between the right and left sides of the face. Therefore, denture borders should be determined by recording the functional position of the vestibular sulcus when the final impressions are made. This is preferable to carving the borders from the processed acrylic resin base. Since all of the borders of the impression are extended only to the functional position of the sulcus and slightly short of the resting position, retention and stability of the base remain good, while the objectives of facial appearance are accomplished. The impression visit is an appearance-phase visit.

Occlusion Contour Rims.—Carefully adapted acrylic resin record bases with accurately formed labial borders are fabricated to carry upper and lower occlusion rims of baseplate wax. The consistent use of these rigid, stable bases has proved to be worth while, even to appearance. If, for example, the record bases slip upon the yielding tissues of the mouth, accurate information is destined to slip beyond the control of the dentist and his technique. No jaw relation record or intraoral procedure related to appearance and the arrangement of anterior teeth can be considered more accurate than the bases upon which it is made.

The labial surface of the maxillary occlusion rim is contoured to the fullness required to support the upper lip naturally in repose and function. The resorbed maxillary ridge form should not be used to control the anteroposterior position of the wax. Rather, this form should be adjusted with consideration for the orbicularis oris muscle and the muscles attached to it. The muscles of expression are unable to function normally without adequate lip support, since their length from origin to insertion is shortened due to the inward sagging of the orbicularis oris muscle. Accompanying this ineffective muscle contraction is the typical denture appearance which is to be avoided.

The length of the wax occlusion rim is altered to conform with the resting position of the lip. Normally, for older patients, the vertical level of the wax is reduced until it is even with the lower border of the upper lip. More youthful patients may require 2 to 3 mm. of wax extending below the lip line.

The midline and the high lip line are located. Finally, the anterior end of the occlusal plane is tentatively paralleled with the pupillary line. After these measurements are completed, the patient is instructed to stand in an erect, yet comfortably relaxed, position. All wax contours are subject to modification and refinement at this time. The patient is engaged in conversation to determine if a natural appearance has been achieved during speaking, smiling, and laughing.

Maxillomandibular Opening.—Tooth loss is characterized by a loss of tissue tone, with the resultant collapse of the cheeks and lips. Not only are the normal

qualities of the mouth and face endangered at the time the teeth are extracted, but distortions are frequently perpetuated by an incorrect or arbitrary vertical dimension. An inaccurate vertical dimension of occlusion may so distort the mouth and face that additional attempts directed toward a satisfactory appearance seem futile.

An excessive vertical dimension is associated with undesirable strained and artificial effects, while an insufficient vertical dimension creates unattractive changes which are characteristic of the aging process. In the latter situation, the chin comes too close to the nose, compresses the upper lip at the center, and allows the corners of the mouth to droop as in a scowl. This upward pressure also induces an inversion and subsequent hiding of the vermilion border of the upper lip. This produces the effect of a thin upper lip and a prominent lower lip.

The final vertical dimension of occlusion must not be determined by pleasing facial proportions alone, since this would lead to excessive vertical dimensions and subsequent destruction of underlying bone.[5] The established jaw separation usually represents a series of compromises between the mechanical and esthetic requirements. A logical starting point is an accurate measurement of the resting vertical position of the mandible by using Pleasure's[6] method of measuring from reference points on the nose and chin. This measurement is decreased appropriately to provide some interocclusal distance and to establish the functional vertical position of the mandible. Unfortunately, there are no means for determining the *exact* interocclusal distance for each patient. At best, an interocclusal distance must be provided which is within physiologic limits and individually determined. During speech, the lower teeth will partially traverse this distance. In the act of swallowing, they will completely traverse the distance, and it is at this level that centric relation must be recorded. Establishing an acceptable vertical length of the face is a fundamental esthetic consideration.

Selection and Arrangement of Anterior Teeth.—The teeth are one of the major elements influencing the appearance of complete dentures. Pleasing effects can be attained best if the teeth are selected and arranged according to the plan of Nature. DeVan[7] has said that five factors govern organization of the dental composition. They are position, proportion, brightness, inclination, and form.

Fig. 1.—A completed anterior composition with the six personalized maxillary acrylic resin anterior teeth arranged in wax. Natural gingival contours are carved to highlight the teeth. This composition must now be studied critically while the patient is in a relaxed standing position with the lips at rest as well as during speaking, smiling, and laughing.

Fig. 2.—A maxillary complete denture with the teeth arranged in wax. The esthetic desires and needs of the edentulous patient have been followed and the results are now ready for analysis by the patient.

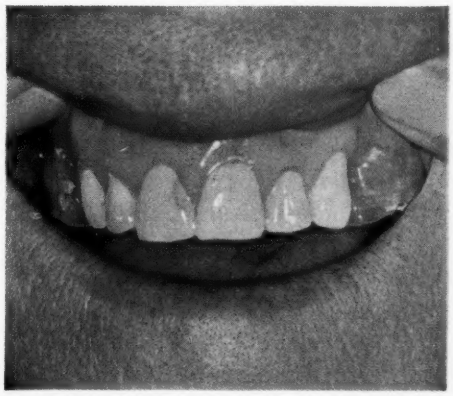
Fig. 3.—The preselected tooth arrangement and gingival outline form faithfully copy Nature's plan for the natural dentition in this upper and lower denture at the try-in stage.

Fig. 4.—A completed denture with teeth which duplicate natural dentition in form, color, and arrangement.

Fig. 5.—Completed upper and lower dentures which tend to defy detection as being artificial. The color and anatomic form of natural gingival tissues have been faithfully copied in the denture bases, while the teeth provide realism by adequately fulfilling the dentofacial objectives.

Fig. 6.—A complete maxillary denture opposing a mandibular removable partial denture. The factors of appearance which govern all dental compositions are particularly evident here. Appearance of dentures never terminates at the cuspid tooth.

Fig. 1



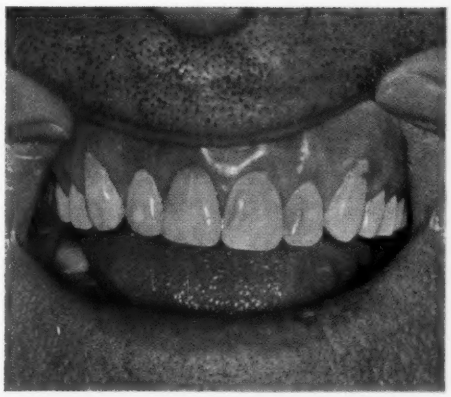
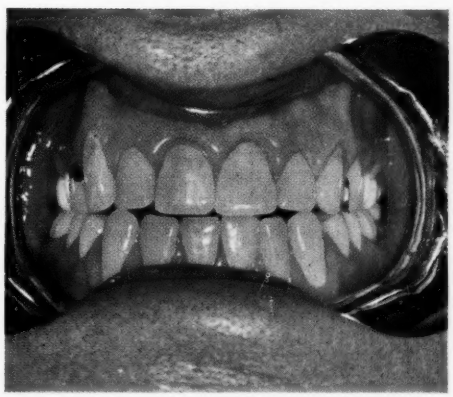


Fig. 2

Fig. 3



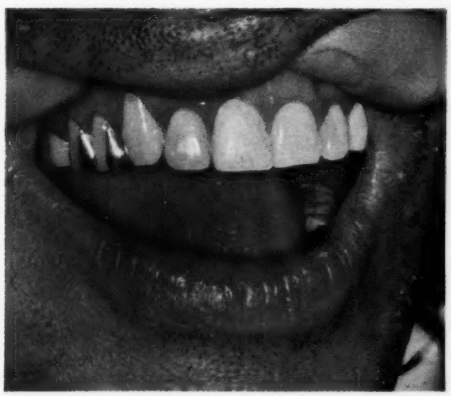


Fig. 4

Fig. 5

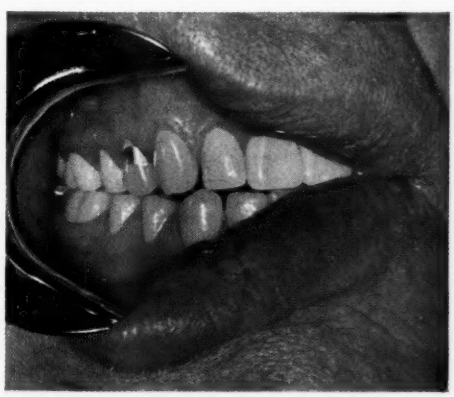


Fig. 6

Figs. 1 to 6.—For legends, see opposite page.

TOOTH POSITION

The basic size, general outline form, and shade of the anterior teeth may appear ideal for the patient, and yet if the teeth are not positioned for the correct support of the cheeks and lips, the effect of naturalness is not achieved. The relative placement of the teeth is determined at the appointment when the upper occlusion rim is contoured. For this reason, an important facet of appearance is established even before the teeth are selected. In the absence of pre-extraction records, the maxillary anterior teeth are carefully arranged to follow the labial and incisal outlines of the wax occlusion rim. This will place the teeth labial to the ridge in most patients.

Both the vertical level of the teeth and their labiolingual position must be in harmony with the surrounding structures of the face if the goal of naturalness is to be approached. Thus, the anterior teeth must be examined while the upper lip is in repose and, also, during an active period of normal facial expression. A further study is made of tooth positions in relation to the lower lip and tongue during speech. The *f, v,* and *th* sounds are especially significant during this testing.

The final positioning of anterior teeth, to achieve pleasing facial harmony, to restore normal lip action, and to prevent a loss of the vermilion contour of the lips, must be done by the dentist. Since the dentist is to determine the position of the anterior teeth, there is a distinct advantage in his devising the compositions in the presence of the patient. Final approval of the anterior composition, by patient and dentist, is reserved until the patient can be observed critically and studied while he is in a relaxed standing position.

TOOTH PROPORTION

Of the two principal tooth proportions, width and length, width is the most important. Once this dimension is known, upper anterior teeth that will harmonize esthetically with the proportions of the edentulous face can be selected. This plan is not an attempt to restrict the dentist's esthetic sense, but, rather, it is a dependable method of tooth selection based upon an average of tooth sizes most often found in patients in middle age who have pleasing natural dentitions. It is based upon Berry's[8] investigation in which he reported that the upper central incisor was approximately one-sixteenth the face width. The research of House[9] substantiated Berry's findings, and DeVan[10] has supported this theory.

In this technique, the dentist measures the bizygomatic width of the face (the greatest width from zygomatic arch to zygomatic arch). The distance is expressed in millimeters and is divided by 16. The selection of the central incisors is based upon this measurement, but it is not a hard and fast rule. Generally, several teeth of slightly varying sizes may be acceptable. By testing sample teeth intraorally and extraorally, the selection is reduced quickly until a final choice of central incisors is made.

After the width of the key teeth (the central incisors) has been determined, the lateral incisors and cuspids are selected individually. Sears'[11] suggestion that narrow lateral incisors are characteristic dental features found in delicate patients, while more rugged individuals require broad lateral incisors, provides the basis for

choosing these teeth individually for each patient. Appropriate breadth deviations in the supporting teeth (lateral incisors) can produce the illusion and effect of either harshness or gentleness. In this way, the teeth may be used to impart personal and distinguishing character traits within a sex, as well as to differentiate between the sexes.

This process of tooth selection is an attempt to correlate the best-appearing tooth sizes with each edentulous face in a reliable, yet easy-to-use, method. Although it is a "hunt and pick method with a definite starting place," it is fundamentally more sound than the common technique of measuring the maxillary arch from cuspid to cuspid in an attempt to relate the size of anterior teeth to the crest of the residual ridge. Teeth are positioned labially to this line on the crest of the ridge, and this nullifies the measurement on the cast. Further, it makes no provision for an irregular tooth arrangement which would alter the combined width of the six anterior teeth. Tooth width is largely dependent upon the proportions of the face.

TOOTH BRIGHTNESS

The color of each of the teeth must be selected individually. To determine a shade from a guide arbitrarily and then use that color for all teeth of the denture seems as illogical as outfitting an entire cast of actors with costumes of the same color. Variation of tooth shades is accomplished easily since it is favorable to the objectives of naturalness. Some degree of color contrast should be used if only to avoid the drab monotonies which direct attention to the teeth as being artificial.

The shade of the central incisors is selected first from an appropriate shade guide. In choosing this shade, the dentist should consider the age of the patient, the individual complexion pattern, and the patient's desires. Acceptable color values of teeth always represent compromises between these three factors. Although our ultimate objective is to devise color changes found in aging natural teeth, this must never be reduced to a simple formula. The statement that dark teeth are indicated for older people is not a valid rule. According to Frush and Fisher,[12] there is a physiologic shade selection which may exert its influence upon the body shade. Individual food and smoking habits produce stains and modify color distribution, and these changes are found even in teeth of a relatively light base shade. Some old people do have lighter tooth body colors than some young individuals, but the darker hue may be the result of natural stain variations.

After consideration of these factors, the color of the dominant central incisors is determined. In selecting the shade for the remaining anterior teeth, a general concept is followed. Lateral incisors are generally more gray than the central incisors, and the cuspids are more yellow. Artificial teeth selected by this method reflect the individual color dimensions of natural teeth.

Denture patients frequently disagree with the dentist when a darker tooth is proposed, even though it may blend harmoniously with their complexion and be indicative of their physiologic or denture age. Since this lightness or darkness is brilliance and not true color, compromises can be adjusted to the patient's desires without sacrificing the major qualities of naturalness in shade.

TOOTH INCLINATION

Complete dentures cannot achieve the goal of being natural in appearance unless the teeth are arranged according to one of Nature's plans. In rotating teeth or "breaking" their alignment in the composition, typical inclinations found in natural dentitions must be followed to obtain pleasing effects.

The setting of teeth so their long axes are parallel is always esthetically poor because of the lack of asymmetry which results. Yet, there must be some *definite plan* for avoiding these monotonous tooth inclinations.

The most positive and dependable method is to select a cast of natural teeth and copy their arrangement. Of course, a cast which has an arrangement of teeth that is harmonious with the facial features of the patient must be chosen. Even after tooth positions have been duplicated faithfully by this method, it must be considered as only the beginning of the setup. Individual irregularities are then introduced to conform with the patient's desires, but these rotational positions must not be contrary to those found in Nature.

Characteristic irregularities of maxillary anterior teeth occur most frequently in the inclinations of the lateral incisors. Lapping the mesial surface of the lateral incisor over the distal surface of the upper central incisor and rotating the mesial surface lingual to the distal surface of the central incisor are the two most common irregularities noted. Dentogenics identifies the first position with introducing gentleness into the maxillary tooth arrangement, while the latter treatment is associated with harshness.

Anterior teeth must be arranged to avoid a predominance of parallelism from both the profile and labial viewpoints. This is the natural appearance that is to be reproduced.

TOOTH FORM

Providing patients with actual reproductions of natural teeth is an ideal method of fulfilling the demands of tooth form. This may be accomplished by constructing permanent metal molds of extracted maxillary central incisors, lateral incisors, and cuspids in flasks. By saving all extracted teeth and preserving only those which indicate a variance of size or shape, a usable supply of flasks can be accumulated rapidly. With this collection of diversified anterior tooth molds, teeth with natural outline forms can be fabricated to coincide with the individual facial features.

Since tooth form can be governed partially by the outline form given to the artificial gingivae, it has been considered the least important element of tooth appearance. The use of personalized acrylic resin anterior teeth adds new value to this factor which was once considered trivial. These teeth represent not only the contour changes, which occur in natural teeth with increasing age, but the natural color and staining qualities as well. They meet the esthetic needs of a natural appearance for each denture patient.

The artistic dexterity of the dentist is obviously more conspicuous when an arrangement of natural anterior teeth is copied than when he merely selects a tooth mold.

The routine use of teeth which faithfully reproduce all of the qualities of their natural predecessors also tends to reduce these artistic compositional demands.

SUMMARY

Progress in any endeavor is not the result of some automatic or magic process. In prosthodontics, the dramatic revival of interest in appearance has been no exception. After satisfactory materials were developed to reproduce the natural hues and contours of the oral tissues and the teeth adequately, dentists were encouraged to apply certain flexible yet practical artistic principles to their complete dentures, based on the individual patient's needs and desires. This provides the basis for a clinical challenge to the lethargic attitude toward complete denture artificiality.

Although naturalness is the key objective for all phases of dentofacial appearance, compromises between the dentist and patient must be met and resolved before these objectives can be accomplished satisfactorily. This meeting of the minds, or mental harmony, is vital to the success of any artificial restoration.

Studies of aging continue to indicate that personal pride and self-respect are not mental phenomena of any specialized or select group. Therefore, the principles of appearance are applicable to the elderly man as well as to the middle-aged woman. But if appearance is to be incorporated into the treatment plan for the denture patient, it must be done intentionally.

Esthetics may continue to be ignored in favor of the mechanical principles of function, but not without sacrifice of a pleasing and harmonious facial expression.

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TERMINOLOGY FOR JAW RELATIONS, TOOTH OCCLUSIONS, AND THEIR CORRESPONDING RECORDS

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CURRENT DENTAL LITERATURE shows a lack of agreement in the use of terms for jaw relations and associated concepts. Even in discussions of denture prosthesis, ambiguity hampers writers and confuses readers.

When the Committee on Principles, Concepts, and Practices of the Academy of Denture Prosthetics tried to formulate certain statements dealing with centric jaw relation, the three members found that they had three different interpretations of the definition in the Academy's *Glossary of Prosthodontic Terms.*[1]

This situation shows the need for clarification and perhaps elaboration of our terminology. One source of difficulty seems to be that we have been trying to get along with too few terms.

The preface of the 1956 *Glossary of Prosthodontic Terms* says, "The lexicographer has a duty to *lead* as well as to follow. Where clearness demands it, he should place such restrictions as are necessary to avoid ambiguity. . . .Where voids exist, he should fill them in." In a developing discipline this process should be a continuous one.

While placing restrictions and filling voids, we should, so far as possible, make the terms suitable not only in isolation but also according to how they can be fitted into the system of names. With this aim in mind, let us see how we can best make communication in the field of dentistry more effective.

JAW RELATION AND TOOTH OCCLUSION

Within limits, we can arbitrarily fix the meaning of any term. A good example of this arbitrary fixing is with the word "occlusion" in dentistry.

When we bring teeth together in or out of the mouth, it is good English to say that we "relate" them to one another. Consequently, opposing teeth may correctly be said to be related. This is a common and proper use of the word "relation" outside of dentistry.

However, the opposing jaws are also "related" to each other. At one time we spoke of "tooth relation" and "jaw relation." This double use of the word led to such confusion that we decided arbitrarily to reserve the word "relation" for the jaws and discontinue its use for the teeth.

This decision necessitated a separate term for the shut position of the teeth, and we agreed to call it "occlusion." It was a happy choice, because "to occlude"

Read before the Academy of Denture Prosthetics in Louisville, Ky.

means "to shut." So now, by common consent, careful writers refer to "jaw relation" and "tooth occlusion."

Although the *Glossary* makes clear distinction between relation and occlusion, some dentists still fail to observe the distinction. This disregard is evident when the term "centric occlusal relation" is intended to mean "centric jaw relation." Some time ago in the *Journal of the American Dental Association,* an authority in his field wrote, "Centric occlusion is the relationship of the jaws when the mandible is closed." Also, in the same journal, some writers used the word "occlusion" where it seems they meant "relation." Such lapses will continue to occur for a time, but their occurrence should be less frequent with the growing reliance on the *Glossary of Prosthodontic Terms.* Nevertheless, there is need for further clarification in the *Glossary* itself.

CENTRIC JAW RELATION

A jaw relation whose definition is important for fixing the definitions of several other concepts is that in which the mandible is horizontally centered with the maxillae. This horizontally centered relation is the one most careful writers designate as "centric jaw relation."

The first pronouncement by the National Soicety of Denture Prosthetists (now the Academy of Denture Prosthetics) in 1925 said, "The mandible is in central relation to the maxilla when in its most retruded position from which the incisor point can make lateral movements."

The same Society gave the following definition in the *Journal of the American Dental Association* of June, 1930: "The mandible is in centric relation when the heads of the condyles are in the most retruded positions from which the jaw can make lateral movements."

Finally, the *Glossary of Prosthodontic Terms* (1956) reads:

"**centric relation** The most retruded relation of the mandible to the maxillae when the condyles are in the most posterior unstrained position in the glenoid fossae from which lateral movement can be made, at any given degree of jaw separation."

The definitions of 1925 and 1930 did not carry the qualifying phrase, "at any given degree of jaw separation." Somewhere along the line this 1956 amendment was slipped into the bill before vote taking. Instead of clarifying the meaning, it has muddled it.

Some dentists interpret this amendment to mean "at whatever degree of jaw separation you want," whereas others interpret it to mean "at a definite but undesignated opening," and still others say it means "at full occlusion." Then there are others who maintain that to be in centric relation, the jaws must be unstrained. Quite evidently, it is time to arrive at agreement as to the *meaning* of "centric relation."

CHOICE OF ADJECTIVES

There is a common word which denotes farthest removed from outer extremes—a midway point or line. The noun is "center" and its common adjective

forms are "central," "centered," and "centric." According to English usage, "central relation," "centered relation," and "centric relation" are common expressions. However, "centric relation" has been chosen for jaw relations because it is well opposed by the word "eccentric"—a word used customarily in mechanics, geometry, and other fields.

The word "center" is used to designate one-, two-, or three-dimensional location. First, there is linear center. The center of a foot ruler is at the 6-inch mark. Second, there is a surface center. The center of a circle is where the still leg of the compass rests. And third, there is a volumetric or three-dimensional center. The center of a sphere is the point farthest from the surface. Let us see how this may be applied to jaw relation.

JAW RELATION

The median mandibular point can be moved horizontally by the patient from full retrusion to full protrusion. We could, if we wished to do so, say that a point on the median sagittal line made by a stylus be designated as "centric relation" when it is halfway between full retrusion and full protrusion. Or, we could agree that the line itself marks centric relation. Any of these definitions would be in accordance with English usage and quite logical.

We also have the clear choice of limiting the definition to the horizontal plane in another way. Centric jaw relation can be located on this plane by a stylus tracing on an opposing horizontal graph plate. The intersection of lines scribed from right and left condyle centers would mark centric jaw relation.

Or again, we could agree that the term "centric jaw relation" should signify what we have just said about its horizontal placement, *plus* the requirement that the mandible must be at a designated vertical position.

We can quickly rule out the first two suggestions of a halfway point on a median sagittal line or the line itself, even though they are logical enough from the standpoint of English. The last suggestion, that of defining centric jaw relation in three dimensions, is open to the objection that it would require replacing a satisfactory definition with an entirely new one for the two-dimensional concept. We should, therefore, favor retaining the satisfactory term of "centric jaw relation" as a two-dimensional designation, and finding some other term for the three-dimensional one.

The device of designating a surface location without regard to its vertical location is not peculiar to dentistry. For example, the geographic location of a point on the globe is given in longitude and latitude without including altitude. If the vertical designation, or altitude, is important, it is given separately.

Or, consider the analogy of the piston and cylinder. In the ordinary hypodermic syringe, the piston is called the plunger and the cylinder is called the barrel. Imagine holding the barrel of the syringe steady in the left hand with the needle pointing up. Then, imagine holding the barrel in the right hand with the plunger part also up. The only way the plunger can be inserted into the barrel is to move the plunger horizontally until it is centered with the barrel. In this relation, the plunger can be inserted partly or all the way to its stop, the plunger remaining always in centric relation to the barrel.

The similarity of the centric relation of the plunger to centric relation of the mandible is clear. Although the movement of the plunger is along a straight line and that of the mandible is along an arc, in both instances the moving part remains in centric relation.

The analogy applies also to the terminal vertical position. The plunger can be carried upward more and more in centric relation until it occludes with the stop at the top of the barrel. It is then in occluding relation.

With a center-bearing stud on one jaw and a horizontal plate on the opposing one or with the occlusion rims present, the mandible is stopped in its vertical movement by the meeting of the stud at the horizontal plate or by the occlusion rims. The mandible is then in occluding relation.

The horizontally centered position which should be known as "centric jaw relation" may be regarded from three standpoints: (1) With reference to the condyles, the mandible is in centric relation when the condyles are in the most retruded positions from which the patient can make lateral jaw movements. (2) With reference to the maxillae, the mandible is in centric relation when in a position from which any horizontal translation produces an eccentric relation. (3) With reference to graphic tracings by a stylus on a horizontal plate, the mandible is in centric relation when the right and left arcs about the right and left condyles intersect.

All of these considerations need not and should not be incorporated in the basic definition, which should read:

centric jaw relation The most retruded relation of the mandible to the maxillae from which the patient can make lateral jaw movements.

This basic definition is valid even after condylectomy, and it should be pointed out that in this definition there is nothing said about where the teeth should be set. However, the definition gives a precise horizontal location, so we can say that we will or will not set them there. The definition says nothing about the degree of jaw separation or strain.

If we agree on this definition and continue the use of the present satisfactory definitions for "rest relation" and "occluding relation," we have three prime definitions around which several others fall neatly into place.

STRAIN

A strained jaw relation is one in which the muscles pull the mandible into some position other than the one it assumes when no force is applied. Such force may be vertical or horizontal or both. In the presence of force, the mandible is said to be in a strained relation, and, by extension, a record made under force is said to be a strained record.

For most purposes, it is desirable to make unstrained records, and for this reason some writers have suggested that the word "unstrained" should be incorporated in the definitions of jaw relations and jaw relation records. However, such adjective qualification is no more justifiable than calling all brides "sweet young brides."

Since the unstrained record is generally desirable, the absence of strain can be assumed unless otherwise stated. For emphasis, or when in doubt, we can use "unstrained jaw relation record," but the word "unstrained" describes only one kind of record. Therefore, the adjective should not be made a part of the definition.

SEVERAL JAW RELATIONS

On the horizontal plane, then, we can have one centric relation and several eccentric ones. Away from the horizontally centered position, we can have protruded, retruded, right lateral, left lateral, intermediate right lateral, and intermediate left lateral relations—all with definitions tied to that of centric jaw relation.

There may be need for a term to designate any position in the median sagittal plane from retruded to protruded relation. This range of positions in the median sagittal plane might be called "median jaw relation." The term "median jaw relation" has been suggested to replace "centric jaw relation." This substitution seems illogical, especially since "median jaw relation" aptly describes a concept not covered in the foregoing definitions. We can define this concept as follows:

median jaw relation The relation of the mandible to the maxillae in which the median mandibular point lies in the median sagittal plane of the cranium.

OTHER NEW TERMS

The term "median mandibular point" was mentioned in describing median jaw relation. This point may be defined as follows:

median mandibular point A point on the anteroposterior center of the mandibular ridge in the median sagittal plane of the cranium when the mandible is in centric relation. For short, it may be called "the mandibular point."

There may also be need for a term for the interval between "rest relation" and "occluding relation." Perhaps the term "intermediate vertical relation" would be useful here. That would leave undefined the jaw relation farther closed than the occluding relation, as well as that farther opened than rest relation. We might wish to devise definitions for these relations.

The tooth occlusion could be similarly named.

JAW RELATION RECORDS

There is need for a set of related definitions to describe the corresponding registrations or records made to establish jaw relations. We could then distinguish between "centric jaw relation" and "centric jaw relation record," as well as between "centric occlusion" and "centric occlusion record."

Jaw relation should be considered as an abstract concept, whereas a jaw relation record is a concrete thing. With the mandible in centric relation, we make a centric jaw relation record; with the mandible in a protruded relation, we make a protruded jaw relation record; etc.

There is no such procedure as obtaining "centric." It is a centric relation *record* or a centric occlusion *record*. The relation record is of opposing jaws; the occlusion record is of opposing teeth or occlusion rims.

The jaw relation record may be centric or eccentric; it may be at a correct or incorrect vertical distance; it may be made with too much closing force; it may be made with unequal pressure on the right and left sides; but it is still a jaw relation record. The qualifying requirements or conditions may be stated, but they should not be made parts of the basic definition of jaw relation record.

The record made for transferring the maxillomandibular relation to the articulator should carry a more suitable name than "the bite." The term "bite" has been marked in the *Glossary of Prosthodontic Terms* as objectionable (Obj.), and rightly so. The *Glossary* suggests in its place the term "centric maxillomandibular registration." This is logical enough, but it is too much to expect that in ordinary conversation dentists will say, "Then, I make a centric maxillomandibular registration"—sixteen syllables for a simple concept. This perspicuous term might be permissable in a scholarly essay, but it can hardly be imposed on dentists for ordinary conversation.

Let us consider some shorter terms. Because the converging stylus tracings on a horizontal plate terminate at centric jaw relation and because the vertical closure terminates at the occluding relation, the terminal position of all movements might be called the "terminal relation" and the record made at this relation might be called the "terminal record." This would be a more descriptive term than "bite." However, the word "terminal" might connote an element of time not intended. "Terminus record" would not be open to this objection, but it still falls short of full description.

The "centric maxillomandibular registration" is actually a record of the position of the mandible in three dimensions. In photography and acoustics we have become more conscious of dimensions, and so we have "3-D" pictures and "3-D" phonographic and radio reception. Why not a "3-D" record of the position of the mandible? It would take the place of "bite" in dental parlance and can be defined as follows:

three-dimensional record (3-D record) The maxillomandibular record at the occluding relation.

It might, under some circumstances, be necessary to specify "centric 3-D record" as we formerly sometimes said "centric bite." However, just as "bite" ordinarily implies a record at centric jaw relation, so would "3-D record" unless otherwise indicated.

CONCLUSION

With refinements and additions for the terms pertaining to jaw relations, tooth occlusions, and their corresponding records, we should be able to make unambiguous statements and thereby communicate effectively.

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CONTEMPORARY CONCEPTS OF ARTICULATION

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Many beliefs concerning articulation have not been corroborated by research. This article is an attempt to separate fact from conjecture. The discussion will be limited to contemporary thoughts on means for duplicating on an articulator the jaw movements found in nonpathologic, natural dentitions and the function of the mouth in mastication.

CHEWING

Although the pattern of chewing varies with the nature of the food being chewed, the following events occur.[1] Before we chew, we get food into the mouth. To do this, the mouth is opened and the mandible is moved to a protrusive or lateral-protrusive position. The mouth is closed and the food is grasped. If the piece of food is to be bitten off, the grasping teeth bite partially through the morsel to produce a thinned-out, weakened area. Then, the hand holding the food pulls in one direction while the head and neck pull the opposite way, causing the food to break at its weakest point. The mouth reopens while the tongue and cheek reposition the morsel onto the lower teeth of one or both sides. Then, the mandible moves up from its lateral-protrusive position and forces the teeth through the food. The lower cusps move past the upper cusps and, in so doing, shear the food. A question exists as to whether the lower teeth contact the upper teeth at this time. The mouth is opened again, the bolus is repositioned, and the procedure is repeated. This continues until the bolus is masticated sufficiently for swallowing. Then, as the food is swallowed and the mouth is emptied, the teeth come together.

The results of an apparently scientific survey of stomatognathic physiology as it relates to mastication have been reported.[1] No maxillomandibular contact was found during chewing per se. However, repetition of the experiment by other observers gave opposing results.[2] The terminal mandibular position was that of centric occlusion, and the teeth were in maximum contact. This position was held briefly until the mandible reopened to resume function or to go into rest position. Chewing was primarily up and down—not side to side; the teeth acted by shearing food, not by milling it. The only lateral or protrusive movements that occurred during mastication were those made while the teeth were not in contact. The lower buccal cusp surfaces sheared past the upper buccal cusps, while the lower lingual cusps sheared past the upper lingual cusp surfaces (Fig. 1). The teeth narrowly missed one another. They did not bump together or glide across one another. It must be assumed that conditioned reflexes and proprioception guided the mandible away from premature tooth contact.

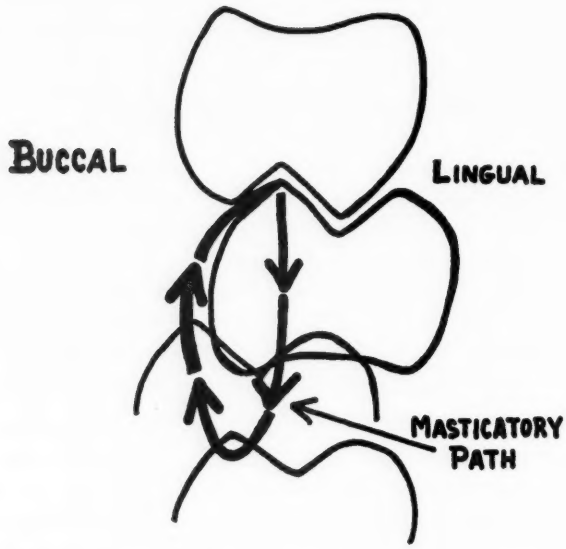

Fig. 1.—The masticatory path of the mandible guides the posterior teeth of the working side toward their upper antagonists. The buccal inclines of the buccal cusps and the buccal inclines of the lingual cusps of the lower teeth shear past the lingual inclines of the buccal cusps and the lingual inclines of the lingual cusps, respectively, of the upper teeth.

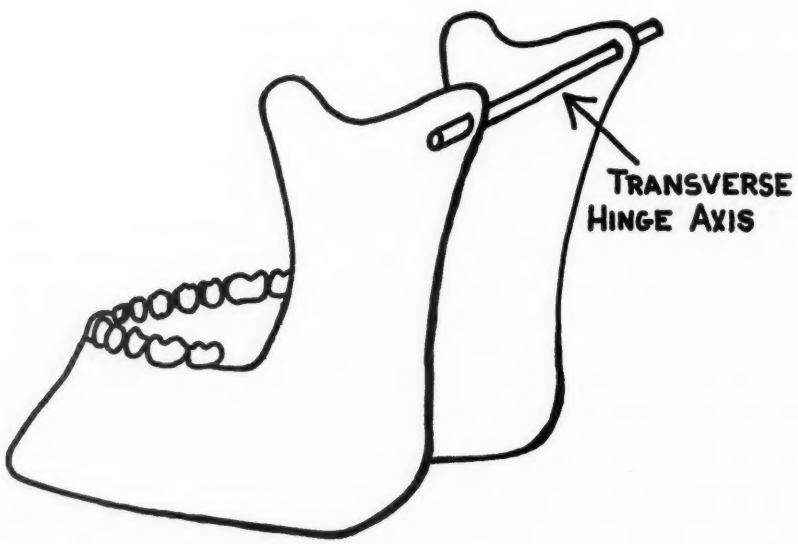

Fig. 2.—The transverse hinge axis is the imaginary line which is the center of rotation about which the most retruded closing movement of the mandible is made.

HINGE AXIS

There has been much discussion regarding the hinge axis, its location, and significance. Nearly all of this discussion has concerned the transverse hinge axis that runs through both condyles from side to side (Fig. 2). This hinge axis is supposed to be the center of rotation around which the most retruded closing movement is made.

The transverse hinge axis is located by rigidly connecting a hinge-bow to the mandible. This can be done by means of a plaster-filled tray which has a protruding stud to which the hinge-bow can be connected. The tray is placed over the lower

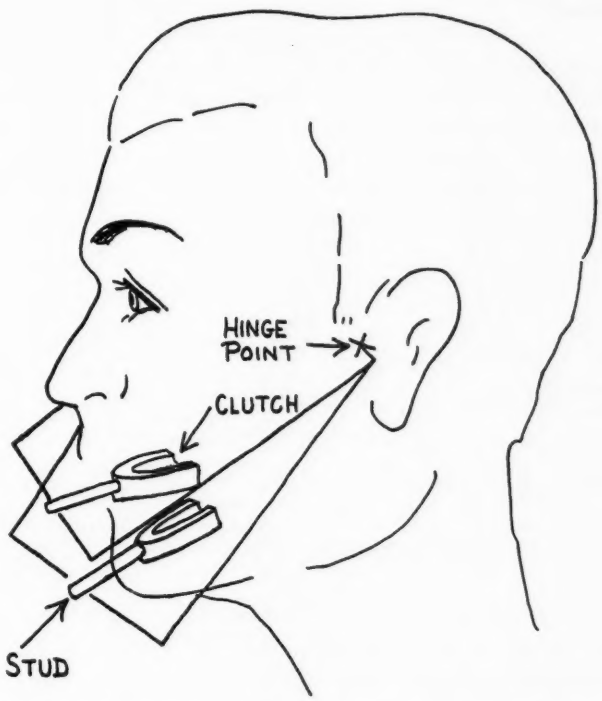

Fig. 3.—The hinge-bow is attached to a stud that protrudes from the clutch, which has been fixed to the lower teeth. The arms are adjusted so that the pointers in front of the ears seem to stand still (rotate only) when the mandible is opened and closed in its most retruded path.

teeth and the plaster allowed to set. The lower jaw is guided through its most retruded opening and closing movements, while the arms of the hinge-bow are adjusted so that the pins in front of the ears do not move across the skin (Fig. 3). When the pins only rotate, the arms of the hinge-bow are locked. Then, the skin is marked with lipstick, dye, ink, or silver nitrate at the hinge points upon which the pins rotated. The hinge-bow is removed, and it will be noted that the points marked are stationary in their relation to the maxillary arch.

A hinge-bow is then locked to the maxillary teeth with a removable orienting device (by means of wax on a bite fork, modeling compound, or a metal clutch), and

the hinge-bow is adjusted to correspond to the previously marked hinge points. This procedure is conducted to allow the apparatus to remain unchanged when removed from the mouth. By means of this assembly, a maxillary cast can be mounted on an articulator in the same relationship to the transverse hinge axis of

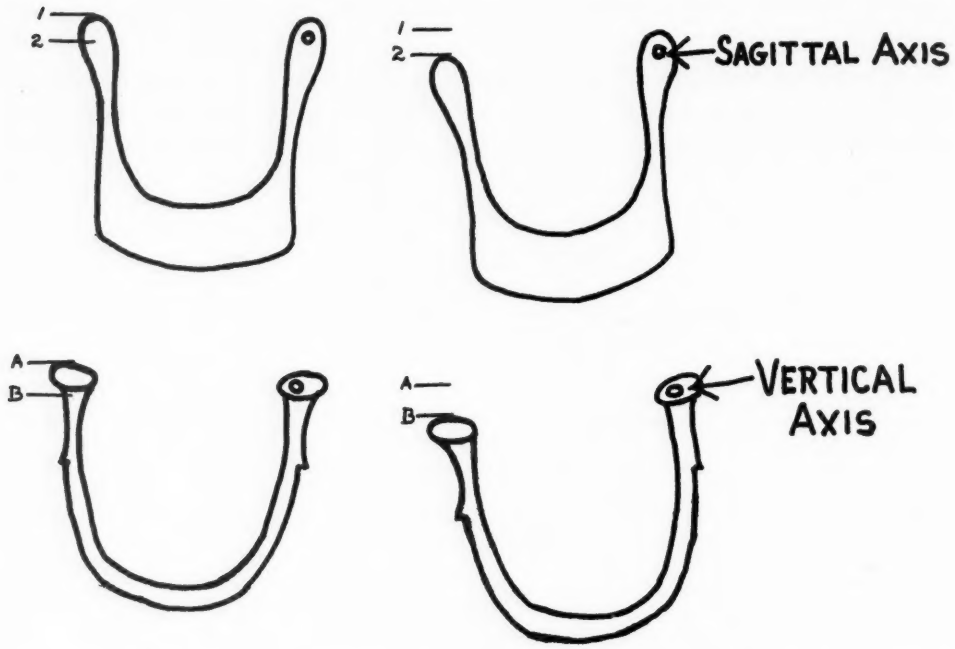

Fig. 4.—Movement of the condyle from *1* to *2* produces rotation of the opposite condyle about its sagittal axis. Movement from *A* to *B* produces rotation about the vertical axis of the opposite condyle and a pure lateral movement. Movements about these axes always occur simultaneously. Pure movement about one axis or the other is never seen.

the instrument as to that of the mandible. A lower cast is later mounted by means of interocclusal records made while the mandible was in a hinge-axis position. All true hinge-axis records, no matter how thick, will fit properly between the two casts if the mounting is accurate and if the axis is located properly. The vertical dimension can be altered as much as 3 or 4 mm. between the mounting of the casts and the completion of the restorations, provided the casts have been mounted accurately on a hinge-axis instrument.

It is remarkable that we are able to record a hinge axis at all. The mandible must be capable of closing on an arc (a portion of a true circle), as opposed to closure on an elliptic, hyperbolic, parabolic, or irregular path. Although no scientific data is available, it is generally agreed that a hinge axis or center of rotation can be located and recorded for most people. Some dentists feel that the hinge axis may be stationary throughout life. Under some conditions, however, the axis is known to shift.

The mandible cannot be forced posterior to the hinge axis position. The temporomandibular ligaments are responsible for this posterior limitation.[3] When

the mandible is forced posteriorly, the temporomandibular ligaments are pulled taut and force the condyles upward so that their anterior portions are against the slopes of the fossae with the menisci interposed. Since the main action of the external pterygoid muscles is to move the condyles forward, the only muscles which seem to act to open the mouth while both condyles remain in hinge-axis position are the suprahyoids.[4] During hinge-axis closure, the temporal, masseter, and internal pterygoid muscles are thought to be active.

In an experiment in which a mechanical hinge was used, the observer could locate many different apparent centers of rotation of the transverse hinge within 0.75 mm. of the hinge's actual position.[5] However, Lauritzen[6] has claimed that, by using a specially designed hinge locator and loupes with 1.6 magnification, he can locate the position of the transverse hinge axis within 0.25 mm. of error.

A hinge axis is a line. Just as the mandible can be forced to open and close about the transverse axis, the mandible can be forced to move laterally about a vertical axis. Two vertical axes exist—one for right lateral and one for left lateral motion. Similarly, two sagittal axes exist for vertical motion (Fig. 4).[7] The vertical and sagittal axes do not necessarily intersect one another or the transverse axis. These axes are used primarily for the orientation of casts to articulators. They are, again, the centers of rotation of extreme, forced movements and are not necessarily associated with normal, habitual movements.

ENVELOPE OF MOTION

The motions of the mandible are limited by the following anatomic factors: (1) posteriorly, by the temporomandibular ligaments, (2) anteriorly, by the capsular ligaments, (3) inferiorly, by muscle stretch, (4) superiorly, by occlusal

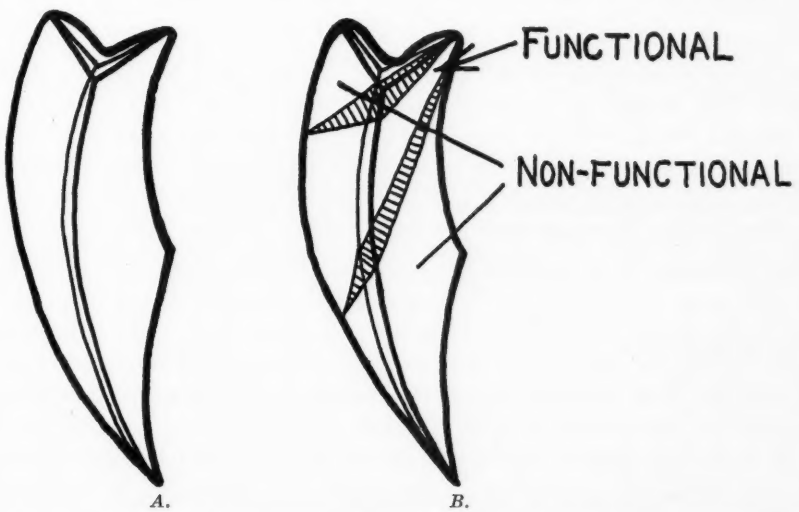

Fig. 5.—*A*, If a steel ball was attached to the mesioincisal angle of a lower central incisor and the mandible moved through all of its possible positions, a complete envelope of motion would be recorded. (After Fig. 9 in Posselt, U.: Movement Areas of the Mandible, J. PROS. DEN. 7:381, 1957.) *B*, If the steel ball was traced during mastication, the functional envelope of motion of the ball would be recorded.

contacts, and (5) laterally, by bones and ligaments.[8] The entire space bounded by these limiting factors is called the envelope of motion (Fig. 5). If one were to place a steel ball on the mesioincisal angle of the lower central incisors and trace its path as the mandible moves through all of its possible positions, the total volume through which the ball moved would be its envelope of motion. The term "functional envelope of motion" is used to differentiate between the complete envelope of motion and that portion of the envelope the mandible actually utilizes during mastication. The functional envelope differs from the complete envelope in only one respect—as the mandible moves in mastication, the maxillae are usually not approached at any angle less than 50 degrees from a horizontal plane; therefore, the teeth do not contact prematurely (Fig. 5). Movements that are outside of the functional envelope are considered to be habitual in origin. Stuart[9] utilizes the lingual carving of the upper cuspid teeth to establish angular limitations. This produces a functional envelope of motion which is referred to as a "cuspid-guarded" occlusion. If we realize that the chewing stroke is usually steeper than 50 degrees, we can understand why chewing is possible in those mouths where lateral balance is lacking.

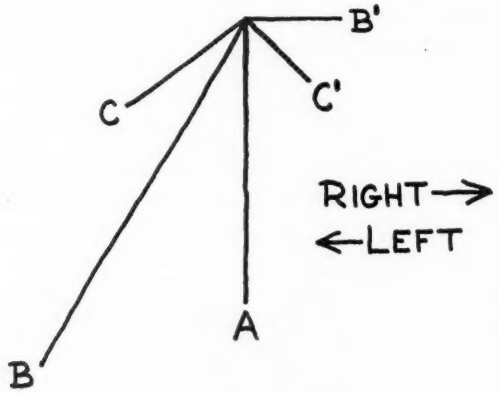

Fig. 6.—Movement of the light over the right condyle during: *A*, extreme opening of the mouth without lateral movement; *B*, extreme opening of the mouth with extreme left lateral movement; *C*, extreme left lateral movement with the teeth in continuous contact; *B'*, extreme opening of the mouth with extreme right lateral movement; *C'*, extreme right lateral movement with the teeth in continuous contact. (After Fig. 8 in Bennett, N. G.: A Contribution to the Study of the Movements of the Mandible, J. Pros. Den. 8:41-54, 1958.)

BENNETT MOVEMENT

One of the most confused aspects of articulation is the Bennett movement. Stuart[10] explains his concept of this movement as follows: ". . . in lateral jaw deflections, the advancing condyle moves downward, forward, and *inward*. Because the two condyles are united by the ramus and body of the mandible, the rotating condyle must move outward equal to the inward movement of the advancing condyle." Stuart does not explain what holds the nonworking condyle against the medial aspect of the fossa during the functional closing stroke of the mandible. Granger[11] describes the Bennett movement as the power movement, yet he records this

"power" movement during the opening rather than the functional closing stroke. Page[12] considers the Bennett movement to be the deviation of the mandible from true sagittal or vertical movement during hinge closure. This is obviously due to the asymmetry of the mandible, and, although Bennett noted this type of movement, it is not the same motion described by Stuart and Granger. There is little, if any, scientific evidence available to validate any of the preceding explanations.

In 1908, Bennett traced the paths followed by the condyles during certain mandibular movements. The source of what is currently called the Bennett movement is Bennett's Fig. 8, line B'[13] (Fig. 6). Here Bennett described the paths taken by lights which were fixed to the mandibular teeth but located near the skin overlying the condyles. He noted that extreme mandibular movements produced specific paths of the lights. It would not be scientific to suppose that the condyles moved exactly as the lights did. After all, the lights were located at a distance from the condyles and their rotational centers. It would also be unreasonable to assume that the mandible slipped laterally during closure (a common concept of Bennett movement), since Bennett seems to have recorded his paths during forced opening movements rather than functional closing movements.[13]

Landa[14] wrote that the Bennett movement as a true side-to-side shift of the condyles was not noted in subjects and skulls he examined, except as a manifestation of pathologic condition. McCollum[15] stated that the Bennett movement is present only when the vertical rotational axis of the condyle lies posterior to the transverse hinge axis. Piecing together the bits of information available, I will present still another concept of what Bennett may have seen when he recorded line B' on his Fig. 8. This explanation is purely conjecture.

First, let us examine what would occur if we were to attach a light to the end of a pendulum and as it swings watch it from various positions. If we were in front or in back of the pendulum, the light would move in an arc from side to side; if we were directly above or below the pendulum, the light would move from side to side; but if we were on either side of the pendulum, the light would seem to move up and down. Fig. 7 represents the appearance of a mandible with lights attached in a manner similar to that used by Bennett. The wires are attached rigidly to the bicuspids and a lens has been placed anterior to the mandible so that the images of the lights may be focused and traced. If the images were traced from above or below, the recording would show an arc anteroposteriorly; if recorded from the side, the images would produce a line running anteroposteriorly. Bennett recorded his images from the front, however, so he could only see a line running mediolaterally. This situation can be compared with viewing a pendulum from the side, and it led to later misinterpretations which seem to be consistent with the facts, but which in reality are fallacious.

AXIS-ORBITAL PLANE

The axis-orbital plane is a modified Frankfort plane, and it is used for the orientation of a maxillary cast to an articulator. It is determined by fixing a pointer to the infraorbital notch or some related anatomic structure. The pointer is locked in relation to the hinge-axis pointers and maxillary arch before the hinge-bow is

removed from the head to mount the upper cast. The plane is determined by the axis-orbital point selected and the two hinge-axis dots. An axis-orbital plane must be utilized in order for an articulator to reproduce any jaw movements other than pure hinge opening and closing.

Where does the mandible belong in relation to the remainder of the head? In a study of 65 white, male subjects with natural healthy dentitions (average age, 23.3 years), the intercuspal position (centric occlusion) was 1.25 ± 1.0 mm. anterior to the posterior border position (hinge-axis position).[16] Most individuals who use a hinge-axis type of articulator for diagnosis or for fabricating prosthetic restorations consider the terminal hinge position to be the ideal maxillomandibular relationship. No one has shown that any optimum mandibular position exists.

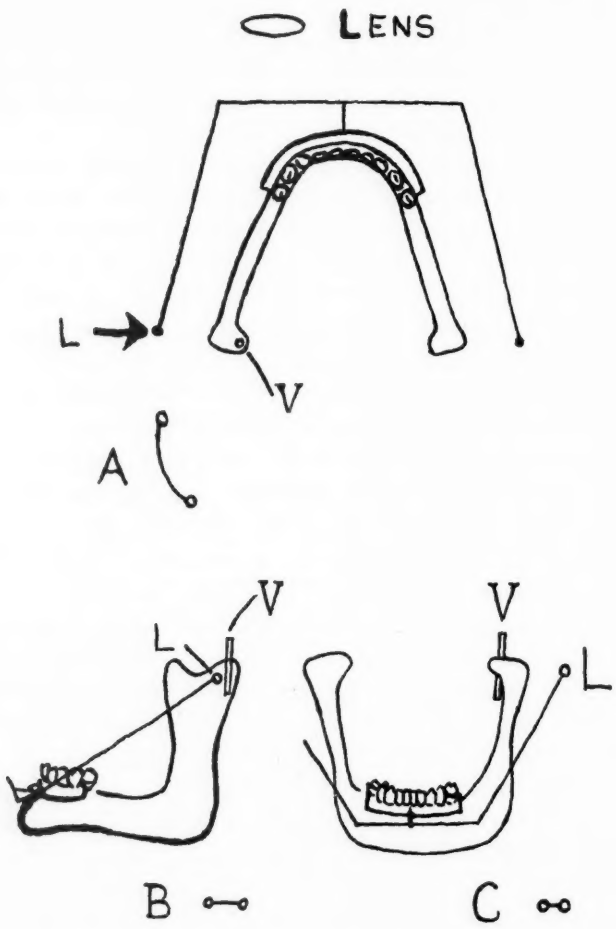

Fig. 7.—The mouth is opened wide with extreme movement to the side on which the light is located. Path *A* represents the path of light *L* of the Bennett apparatus when viewed from above or below and is similar to the path of a pendulum when viewed from in front or behind. Path *B* represents *L* when viewed from the side and is similar to the path of a pendulum as seen from above or below. Path *C* represents Bennett's actual view of *L* from in front and is comparable to the view of a pendulum from the side.

Many dentists consider it essential to accurately record and duplicate condyle paths in utilizing an articulator. However, condyle paths are always determined by opening movements—those movements in which the external pterygoid muscles are active in maintaining contact of the condyle to the fossal slope. During closing movements (function occurs only in closing movements), nothing maintains the relationship of the condyles to the slope of the fossae, so it is quite possible that our efforts in recording the condyle paths are in vain. McCollum[15] has stated that recordings are made during opening rather than closing movements, because tracings of the closing strokes would complicate the records. It would seem, then, that during closure there is no predictable path that the condyle will follow.

Wherever my opinions have been presented in this article, an attempt has been made to be objective and to subjugate my personal feelings. It is possible, however, that undue emphasis may have been placed on some of the ideas about which I feel strongly. It must be understood that progress is made only through scientific endeavor; supposition merely creates questions for experimental evidence to answer.

SUMMARY

1. Many beliefs about articulation have little or no scientific support, and some have been shown to be untrue.

2. The physiology and anatomy of mastication must be considered in jaw movement duplication.

3. Differences of opinion exist as to where the mandible belongs in relation to the relatively fixed maxillae.

4. The confusion and mystery surrounding the subject of articulation can be overcome. All principles involved follow basic laws of physics and geometry.

5. Perhaps the gravest error that dentists make is that of misinterpreting the results of scientific experiments.

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USE OF PLASTICS FOR PATTERNS FOR REPAIRS

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A broken tooth under a clasp or bridge can be restored with the use of resin materials for patterns. A pin and collar of resin may be formed for a foundation and the pattern corrected within the clasp. Or, a gold casting may be made over a stone die, if desired, and then it can be added to by waxing to form and investing in Steele's investment.

A bridge abutment can be repaired in the same manner if the bridge seats perfectly otherwise. An inlay *under* an inlay may be made with the same care that an inlay pattern is prepared in a normal cavity.

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THE TRIAD OF THE OCCLUSION, MUSCULATURE, AND TEMPOROMANDIBULAR JOINTS

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INTEREST IN OCCLUSAL EQUILIBRATION, rehabilitation, and treatment of temporomandibular joint dysfunction is expanding current dental procedure. These terms usually are considered separately as somewhat distinct clinical procedures; however, in reality, they comprise only aspects of a single complex mechanism.

A dentist who works daily with articulators, occludes casts, and manipulates all sorts of mechanical reproductions of oral structures can become understandably mechanistic in his thinking. He may believe that the mandible is brought into a certain relation to the maxillae by the passive manner in which the maxillary and mandibular teeth occlude. Or, when he examines a denture patient for whom proper maxillomandibular relations were not established, he may believe there is a dominance over the occlusion by the temporomandibular joints.

Actually, the truth lies somewhere in the middle ground. Casts which reproduce tooth arrangements and articulators designed to simulate joint movements often fail to relate the masticating mechanism in its proper perspective, since the activating component, the musculature, is missing in the dental laboratory.

NEUROANATOMIC CONSIDERATIONS

Sherrington[1] classified sensory receptors into four groups: (1) exteroceptors concerned with environmental changes in the skin, (2) interoceptors receiving impulses from the viscera, (3) teleceptors receiving impulses from the eyes, ears, and nose, and (4) proprioceptors concerned in the movement of body parts and relating those parts in space.

Proprioceptive nerve endings are found in skeletal muscles and in their tendons; among these are the muscles of mastication. Also, these sensory receptors are located in the temporomandibular joints and in the periodontal membranes of the teeth. This proprioceptive system coordinates the movements of the body that are automatic or unconscious, such as walking or mastication. The sensory impulses which are transmitted by the proprioceptive nervous system very seldom reach the thalamus and consciousness.

Under the stimulation of pain, pressure, or temperature change, exteroceptor nerve endings in the oral cavity transmit impulses over a pathway in the trigeminal nerve to the brain stem and finally to the thalamus and consciousness. Although the

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proprioceptive impulses elicited within the periodontal membranes of the teeth travel over the same sensory nerves of the lower two divisions of the trigeminal nerve, they are transmitted along a distinct pathway and, also, find their way to the brain stem. At this point, however, when mastication is not consciously controlled, these impulses may be transmitted to a special nucleus of the trigeminal nerve within the brain stem called the "mesencephalic nucleus." When mastication is voluntary, these impulses follow another pathway to the thalamus and consciousness. As a rule, however, a reflex arc is completed by a synapse with cells in a motor nucleus of the trigeminal nerve found also in the brain stem close to the mesencephalic nucleus. The efferent fibers then carry impulses along the motor division of the trigeminal nerve to the muscles of mastication.

Corbin and Harrison[2] have shown that the mesencephalic nucleus is responsible for the reflex control of mastication. Therefore, the muscles of mastication are not necessarily controlled by impulses arising from the conscious level of the brain, but rather from sensory impulses emanating from proprioceptive receptors found within the periodontal membranes of the teeth.

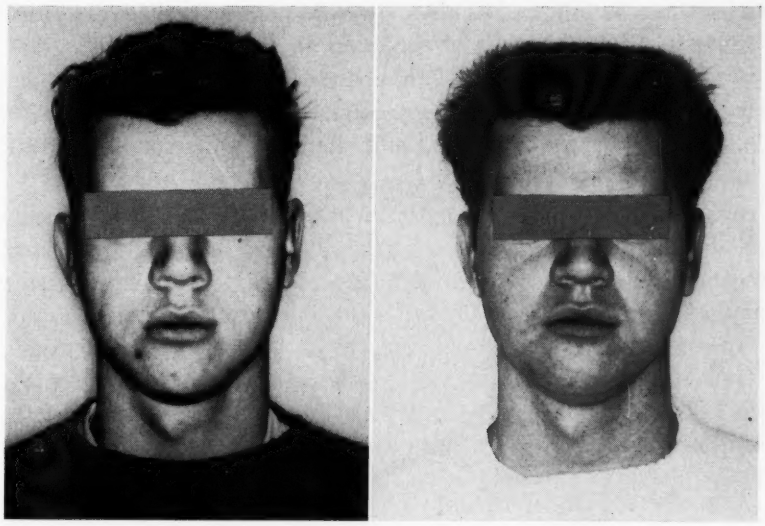
CLINICAL IMPLICATIONS

Natural teeth are moving and changing their positions daily. As occlusal and proximal wear continues, deflective occlusal contacts and irregularities develop, but if these are not too severe, daily adjustment occurs. This adjustment cannot occur for gross irregularities, improperly placed restorations, or certain malocclusions, and sensory impulses are transmitted continually to the mesencephalic nucleus via the proprioceptive fibers. Since this system seems to be protective in nature, motor impulses direct the muscles of mastication to place the mandible into a position in which there are less interferences. The position is one in which the least number of impulses are elicited by the sensory receptors.

Perry,[3] in the light of these implications, concluded that over a period of time an occlusal position is found in which there is the least amount of interference. The muscles of mastication, at the expense of their own welfare, maintain this position with each occluding movement.

This explanation, although extremely simplified, forms the rationale by which one may diagnose an abnormal maxillomandibular relationship as a result of interferences found in the occlusion of the teeth. When patients who have developed a mandibular displacement or an eccentric occlusal position become edentulous and lose the proprioceptive sensory receptors that the periodontal structures afford, the muscles of mastication can begin once more to function normally and the displacements are eliminated quickly. However, they may reappear if improperly constructed dentures are inserted.

With loss of the teeth, the patient loses the contribution which the proprioceptive mechanism of the periodontal structures of the teeth affords. That is, the masticating muscles no longer receive directive messages which dictate the path of closure of the mandible, and the patient finds it difficult to relate the mandible in space. This loss of mandibular perspective poses one of the most formidable problems the prosthodontist must face in maxillomandibular registrations.



A. *B.*

Fig. 1.—The patient had a slight mandibular deviation *(A)* which was corrected after treatment *(B)*.

ELECTROMYOGRAPHIC EVIDENCE

The electromyograph can be used to discern abnormal muscle activity in patients who are accommodating for irregularities and interferences in the occlusion by establishing an abnormal maxillomandibular relation.[3,4] The imbalance that occurs due to abnormal motor impulses from the positional and postural muscles of the mandible eventually reflects itself in an abnormal resting state. These muscles, when examined electromyographically, do not give the typical resting recording because of the constant protective motor impulses and the slow accumulation of harmful by-products of muscle activity. A condition of spasm occurs which gives a typical recording on the electromyograph. Such spasms are seen most frequently in the posterior part of the temporal muscle which aids in the retraction of the mandible. Correct clinical procedures in the nature of occlusal equilibration, splinting, etc., can be observed by the elimination of this spasm record after a few days. Actually, the whole arrangement of muscles throughout the head and neck is intricately interrelated so that a malfunction in one muscle may reflect itself in a far distant muscle group.

ROENTGENOGRAPHIC EVIDENCE

Thompson's[5] demonstration of the stability of the rest position and interocclusal distance has led to considerable insight concerning the path of closure of the mandible. This demonstration has offered a reliable starting point from which mandibular movements may be evaluated. By obtaining cephalometric roentgenograms on a patient whose mandible is in the rest position and the occlusal position and then superimposing the facial structures of one on the other, the path of closure

of the mandible can be followed. This allows the dentist to diagnose an abnormal path of closure in an anteroposterior direction on the lateral cephalogram, and it also discloses lateral displacements of the mandible as recorded on the anteroposterior cephalogram. Certain types of malocclusions are predisposed to these displacements, and by properly diagnosing and eliminating the condition, nearly complete correction of the malocclusion can be obtained.

The cephalometric roentgenogram does not, however, allow a good view of mandibular displacements in the temporomandibular joint. Temporomandibular joint roentgenography must be used for a more detailed analysis of these changes. The technique involved is similar to that of cephalometric roentgenography in that successive roentgenograms on the same individual can be superimposed with a high degree of reliability. This means that a head positioner should be employed to stabilize the head and relate it to the roentgen beam in a constant manner. A technique which has proved reliable is Donovan's modification of the Lindblom apparatus.[6] Another acceptable technique has been presented by Updegrave.[7]

CLINICAL EVIDENCE

Inspection of the soft tissues of the face often discloses an asymmetry because of a lateral mandibular displacement in the occlusal position. The path of opening and closing, the midline relation of the maxillary and mandibular central incisors, the abrasion pattern of the teeth, the interferences during eccentric movements of the mandible, teeth which are hypermobile due to deflective occlusal contacts, and

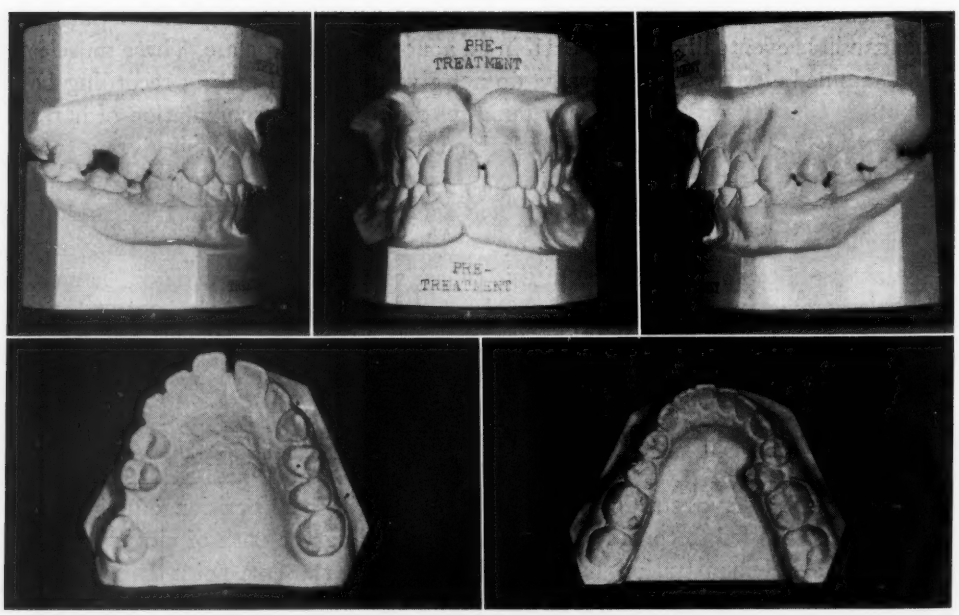


Fig. 2.—The pretreatment casts show the anterior vertical overlap, the midline deviation, and the posterior occlusion.

clicking and popping of the temporomandibular joints are only a few of the signs which should be observed and can be used in diagnosing the patient's problem.

A careful record of information obtained directly from the patient can be significant. Subjective symptoms may consist of pain in the joint region, pain in the

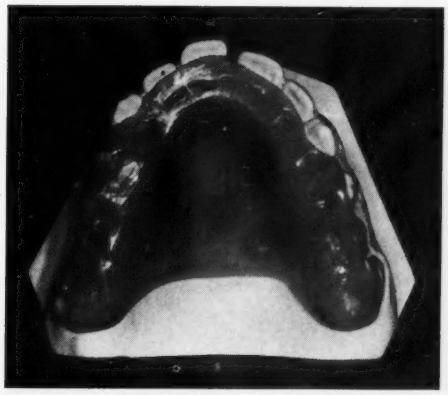


Fig. 3.—The occlusal splint is in position on the upper study cast.

temporal and postauricular region, and temporal headaches. Some patients may state that a certain tooth or teeth seem to be in the way when they close or move their mandible or that certain teeth may be sore from time to time. A proper diagnostic work-up on a patient, including study casts, photographs, cephalometric and temporomandibular joint roentgenograms, electromyographic records, and a thorough clinical examination, can usually produce the proper diagnosis when a malfunction of this "triad" exists.

TREATMENT OF THE TRIAD

The treatment of a disturbance within this triad is the restoration of a proper maxillomandibular relationship and the elimination of cuspal interferences during

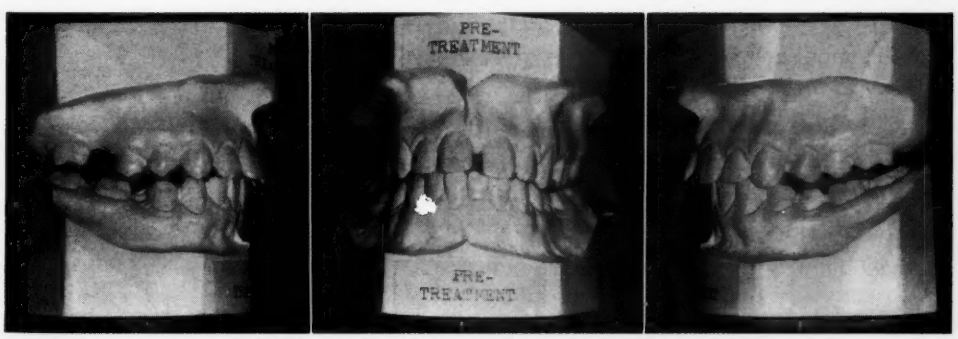


Fig 4—The occlusal splint allows the mandible to assume a normal position by eliminating the interferences that caused the displacement.

the masticating movements of the mandible. Such treatment results in normal proprioceptive sensory impulses from the periodontal structures of the teeth, allows for normal muscular action, and results, consequently, in the proper relationship of structures within the temporomandibular joint. Definitive treatment may consist of equilibration, splinting to re-establish proper maxillomandibular relationship prior to construction of a rehabilitative prosthesis, mouth rehabilitation, or orthodontic movement of teeth.

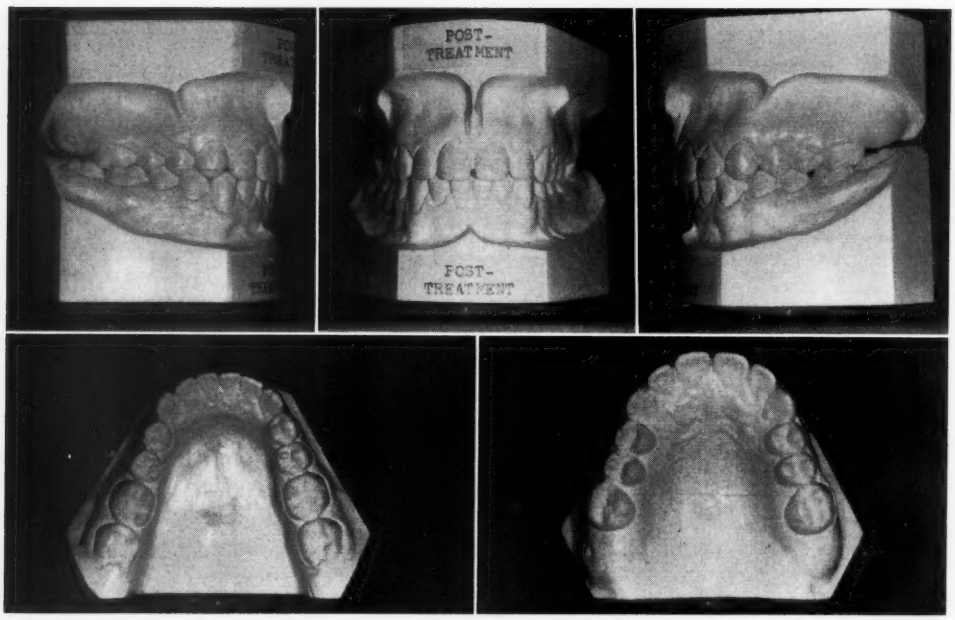


Fig. 5.—The posttreatment casts show the corrected midline relationship, the corrected vertical overlap, and the corrected occlusion.

Many combinations of treatment are possible, depending on the individual patient. Temporary splints can be used in conjunction with orthodontics, mouth rehabilitation, or even the more simple treatment of equilibration. The use of a temporary splint allows, by the elimination of the occlusal interferences, proper maxillomandibular relations to be established.

Injections are used in the treatment of temporomandibular joint dysfunction, particularly for arthritic conditions. However, re-establishing occlusal harmony and muscular balance is usually sufficient to eliminate the clicking, popping, pain, and other symptoms associated with joint disturbances.

CASE REPORT

A white, male patient, 19 years of age, had a generalized malocclusion with occasional pain and "clicking" in the right temporomandibular joint. There was only a slight mandibular deviation to the right (Fig. 1).

Clinically, the midline was deviated to the right (Fig. 2), partially because of shifting of the teeth. Both maxillary first permanent molars had been extracted previously, and the space was practically closed on the left side by the mesial drift of the maxillary second permanent molar. Intraoral roentgenograms disclosed that there were unerupted third molars present and that the remaining teeth and investing structures were in good condition.

Opening and closing movements revealed that the midline was in better relation in the rest position than in the closed position and that the mandible deviated

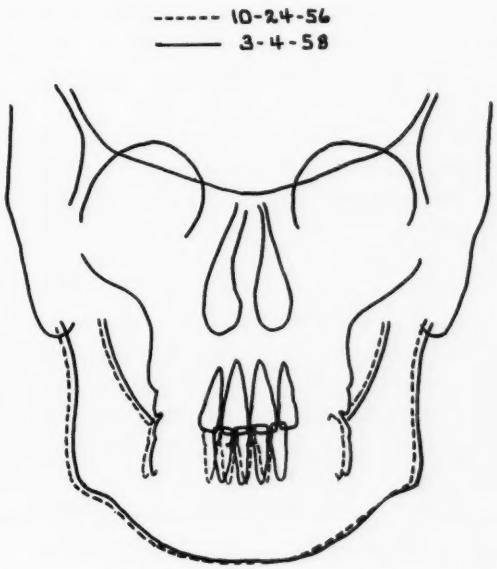


Fig. 6.—The pretreatment and posttreatment tracings indicate the degree of correction.

to the right on closure. This lateral deviation was partially responsible for the midline discrepancy. Gross tooth interferences could be observed and abnormal occlusal wear was apparent on tooth surfaces of initial contact. Pretreatment anteroposterior cephalometric roentgenograms confirmed the observation of the mandibular displacement. Treatment of this abnormal maxillomandibular relation was considered important in treating the malocclusion, since the malocclusion itself was responsible for the abnormal function.

A temporary occlusal splint (Figs. 3 and 4) was constructed which allowed the mandible to assume an occlusal position more compatible with the rest position and restored a normal path of closure. The thickness of the splint remained well within the interocclusal distance, and all interferences of lateral excursions were eliminated. The patient adapted to the splint quickly, and all temporomandibular joint symptoms were eliminated within the first week. Then, the splint became an integral part of the orthodontic treatment, by eliminating the interferences causing the displacement and by holding the proper maxillomandibular relation until the posterior occlusion could be corrected. Posterior occlusal parts of the splint were

removed progressively during treatment and, later, by building up the anterior section, the splint was used to help correct the anterior vertical overlap.

The corrected midline (Fig. 5) was obtained partially by tooth movement and partially by mandibular repositioning. The maxillary right second permanent molar was moved forward to eliminate the necessity of a prosthetic replacement, particularly since the maxillary third molars were present and could then erupt into the second molar positions.

The tracing of the pretreatment and posttreatment anteroposterior cephalometric roentgenograms (Fig. 6) demonstrates the degree of correction resulting from the establishment of the correct maxillomandibular relation. The retention has been removed from the teeth and they have shown no tendency to return to their former position. Further, there has been no recurrence of temporomandibular joint symptoms.

Certainly every dysfunction relating to the "masticating triad" is not of this particular type. Yet, this patient demonstrates the part that occlusion plays in the proprioceptive control of function and the role orthodontics can play in re-establishing proper function.

CONCLUSIONS

It would seem, in retrospect, that as the proficiency of the dentist increases and his diagnostic ability improves, there are fewer patients classified as neurotic and fewer conditions which are diagnosed as psychogenic in origin. A failure to obtain the desired result for a patient must, in all fairness, be considered to stem from an incorrect treatment procedure.

The "masticating triad" is a complex and beautifully integrated mechanism which functions efficiently for a lifetime for most people. The dentist who would treat its malfunction, however, must master its physiology.

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THE TEMPOROMANDIBULAR JOINT IN PROSTHODONTICS

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AN ARTICULATOR IS a prosthetic tool. It is to the dentist what the square and saw are to the carpenter or the violin is to the maestro. An articulator is a mechanical instrument used to reproduce the functional relations of the teeth as they come together in the mouth. The reason for using an adjustable articulator is, figuratively speaking, to transfer the patient to the laboratory bench. The trained laboratory technician can then perform many of the procedures so tediously and ineptly performed at the chair.

ARTICULATOR USE IN PRACTICE MANAGEMENT

There are many reasons for the need for a good articulator. Perhaps one that is little understood is its importance to good practice management. The articulator makes it possible to delegate a major portion of the work to the laboratory technician, thereby giving the dentist more time for productive work. It is frequently said that Gnathology is not practical, that it is too complicated. The real truth is just the reverse. The more faithfully the instrument reproduces the positions and the movements of the jaws, the better the laboratory technician can perfect the restoration. Properly constructed, such restorations require no adjustment in the mouth. One hour devoted to securing a precise pantographic record of everything the patient can and does do saves untold hours of mouth procedures which are tedious and exhausting to both the patient and the dentist.

VARYING TECHNIQUES

There is no such thing as *one* technique for the use of such an instrument any more than there is one technique for performing any operation. Once the instrument has been adjusted to reproduce the relations and movements of the jaws, the treatment prescribed by the dentist is the same as that which he would use regardless of the instrument. The instrument does not dictate any restoration or cusp form any more than does the mouth itself. It does enable the dentist to determine how well his restoration is going to work before it is transferred to the mouth.

Some dentists decry the need for a "complicated" articulator and state that many acceptable restorations have been constructed on "simplified" instruments. There is no doubt that a skilled dentist can get by with such instruments, but he does so at the expense of his own time and energy. To justify such procedures because the instruments are simple is like trying to justify a model T Ford in

Read before the Academy of Denture Prosthetics in Louisville, Ky.

comparison with the modern automobile. After all, even a bicycle will get you there but it is not practical.

Today restorations are constructed which a few short years ago would have been beyond the reach of most patients. Dentitions which previously would have been condemned can be restored to many years of health and usefulness. Our ability to treat such dentitions is directly related to our ability to transfer jaw function to the restorations. Whatever type of restoration is indicated, be it flat teeth, 20-degree teeth, cusp teeth, or inverted cusp teeth, that restoration can be constructed better using an accurate adjustable articulator.

TEMPOROMANDIBULAR JOINT

Clinical experience points to a relationship between functional movements in the temporomandibular joints and pathologic processes occurring in the jaws. The patient's ability to accept and tolerate restorations is dependent upon many psychologic factors, but we cannot ignore the functional ones. Although the simplified articulators of the past bore a faint physical resemblance to the temporomandibular joints, they failed to reproduce any of the important functional jaw relations. Restorations constructed on such instruments could not function in the mouth without major adjustments which destroyed much of the work so carefully executed. As a result, many dentists became convinced that there is something so complex and mysterious about the temporomandibular joint that it cannot be reproduced on a mechanical instrument, because it is living tissue and cannot be reproduced by brass and steel. At first glance this does seem sensible. However, an articulator does not reproduce the anatomic structures of the joint. The articulator should copy the functional effects of the anatomy. Our restorations are mechanical replacements of anatomic structures. Just because they are mechanical does not mean that they cannot be physiologic.

The prosthetic relations of the joint are those actions of the joint which enter into, or create problems of, tooth restorations. They are not concerned primarily with the anatomy of the joint, but rather with the way that anatomy enters into functional relations of the teeth, either natural teeth or their artificial counterparts. Properly articulated teeth do not bump into each other and thus create lateral stresses. Instead, they travel around and between each other to create a most efficient chewing mechanism while maintaining force along the long axes of the teeth to reduce stress on the supporting tissues.

MANDIBULAR MOVEMENTS

The movements of the mandible which create the multitude of tooth contacting positions are activated by the muscles of mastication but controlled by the temporomandibular joints. The muscles place the mandible in a great variety of positions, but the paths of motion to these positions are determined by the joints. Because the mandible is capable of such an infinite variety of movements, many dentists think that the joints are loose, sloppy, and incapable of precise direction.

The temporomandibular joint is unique in some respects. It is not held together by the ligaments. The ligaments are loose, which enables the joint to

perform its gliding actions, and they serve to limit its paths. The *muscle* action holds the joint together and overcomes the resistance between the teeth. As a result, when the muscles are at rest the joint hangs loosely suspended by the ligaments. So, at rest this is a loose, sloppy joint; but, when the muscles contract to overcome resistance, the joint is drawn tightly together to brace the condyle so that the muscles *can* exert force.

The mandible is capable of an infinitive variety of paths of closure, but there is nothing loose or sloppy about it in function. The mandible seldom makes a pure hinge closure, and that is not the purpose of a hinge axis mounting. By the degree to which an articulator fails to duplicate these paths of motion, it fails to be a good prosthetic tool. The muscles can adjust the mandible to any position that is harmonious with the functional paths of the joints. However, the muscles cannot permanently adapt the mandible to a position which is not harmonious with the joints without injury to some part of the mechanism, be it teeth, supporting structures, joints, or the muscles themselves.

JOINT ACTIONS

Much of the air of mystery which surrounds the temporomandibular joint is the result of the failure of articulators to duplicate its function. Attempts to copy the anatomy did not succeed because the resulting instruments lacked the adjustability and variability of the anatomy.

There are four basic actions which occur in the temporomandibular joint. In the lower compartment, the condyle rotates on the meniscus with an action similar to that of a ball and socket. In a normal joint, the lower compartment is capable of only rotary action. This rotation occurs around an axis which in opening and closing movements is referred to as the *hinge axis*. The mandible is always asymmetrical, and the condyles are irregular bodies. It is the form of the meniscus which makes this rotation possible. Since the mandible is a rigid body and one condyle cannot rotate without the other, it must rotate about a single axis.

In horizontal motion, the mandible rotates about an axis which is referred to as the *center of rotation.* (Anatomists seem to be in agreement that the center of rotation lies in the condyle and is not some imaginary point behind it.) The place where the center of rotation intersects the hinge axis is the *axial center* of the condyle. It is the relation of the teeth to this axial center that enables the cusps to pass each other without bumping and creating lateral stresses. The precise adjustment of the correct center of rotation to the restoration is the most important requirement of an articulator. This can be accomplished only by accurate registration and adjustment on the instrument of the correct intercondylar distance. No "Bonwill triangle" or similar average can suffice.

While the condyle is rotating on the meniscus, the meniscus is gliding in the glenoid fossa. These two actions always occur simultaneously. In any normal muscular action, the patient cannot use one compartment of the joint without at the same time moving the other. The fact that these two totally different actions are going on *simultaneously* is the cause of the seemingly mysterious complications and is one of the major problems in obtaining a correct centric relation record.

The path of closure is a resultant of both rotation and gliding of the condyle, but with a different combination depending upon where it started. The pathway is never twice alike.

MENISCUS PATHWAYS

There are three basic paths of motion of the meniscus in the fossa. In a pure protrusive path, both condyles glide down and forward equally and simultaneously. On a lateral excursion, the condyle on the working (chewing) side slides across the fossa in the Bennett movement. So the center of rotation, which is in the condyle, slides across the fossa as the condyle is rotating on the meniscus. In order for the working condyle to rotate and glide across the fossa, the condyle on the balancing (opposite) side slides forward, down, and in along a different path than it followed in protrusive movement. In function, all of these paths are return paths to and through centric relation.

The patient uses various combinations of these paths, with various rotations in the lower compartment, to produce an almost infinite variety of paths of motion of the mandible. In function, the paths are rarely twice alike. As the consistency of the bolus changes with various foods, the combination of pathways changes constantly. Movements of the mandible which result from this ever-changing combination of paths are all rotary movements. The paths of motion of the teeth are, therefore, the result of paths of motion of the hinge axis, since the center of rotation lies on the hinge axis. It is this maze of complex movements of the mandible which determines the cusp form and position necessary to establish harmonious functional balance of teeth, joints, and muscles.

ARTICULATOR MOUNTINGS

At first glance, the correct mounting of the casts seems very complicated and difficult. Actually it is not. It requires only two relatively simple procedures. If the hinge axis is located and the three basic paths which it follows are reproduced, these paths can be recombined to create every possible movement of the teeth and mandible. The purpose of an articulator mounting is to reproduce on a mechanical instrument the same relation of the casts to the axis of the articulator that the teeth have to the axis of the mandible. The purpose of articulator adjustments is to reproduce on the instrument the paths of motion of the axis. We dare not do one without the other. We cannot deal with one compartment of the temporomandibular joint by a simple hinge axis mounting or a centric relation record and ignore the paths of motion, because this is something the patient cannot do. He is compelled to use both compartments every time he moves the jaw. To ignore the precise location and the paths of motion of the center of rotation is sure to result in making a troublesome matter worse.

The myth that this is a complicated and difficult procedure has been destroyed by the fact that students with no previous experience and no notions to unlearn are executing these procedures in the routine clinical treatment of patients. Within 6 months after Gnathologic treatment was introduced into clinical practice, the students had mastered it and had completed a large number of successful restorations..

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REGISTRATION OF THE CONDYLE PATH INCLINATION: VARIATIONS USING THE GYSI TECHNIQUE

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THE VARIATION OF THE CONDYLE PATH INCLINATION as recorded by intraoral wax records has been examined previously.[1] The aim of this investigation is (1) to assess any variations of sagittal condyle path inclination as obtained by graphic recording and (2) to compare them with the results obtained from the intraoral wax record method.

In the Gysi technique, the condylar rods of the face-bow make tracings on cards held on the balancing sides during alternate lateral movements.[2-4] A waxed glass plate was substituted for the card in this investigation.

MATERIAL AND METHODS

Ten undergraduate dental students, 9 men and 1 woman, were used as subjects in the investigation. The mean age was 23 years (range, 20 to 31 years). All subjects had complete or almost complete complements of teeth.[5] Ten registrations were made on each side of each subject's mouth by means of a Gysi face-bow (Fig. 1).

An acrylic resin tray (Fig. 2), similar to the Hanau clutch tray,[6] was fixed to the lower jaw by means of modeling compound and dental cement. The vertical dimension of occlusion was increased approximately 4 to 5 mm. This amount of increase in vertical dimension should not influence the registrations, since during the terminal hinge movement the condyles remain in their fossae.[5,7] The lower occlusal plane and the side arms of the face-bow were made parallel.

Contact between the upper teeth and the tray was established after terminal hinge closure, and a waxed glass plate was placed between the skin and the condylar rod of the face-bow. The lower edge of the glass plate was held at right angles against the mirror plate (Fig. 1). The condylar rods of the face-bow were directed against the average condylar points. Then, the subject performed lateral excursions.

The ten registrations were made on one glass plate, and the tracings were etched into the glass with sodium fluoride. The glass plate was placed on a viewing box, and the curves were traced on tracing paper. The edges of the glass plates and of the paper were kept parallel, thus presenting the relationship to the occlusal plane.

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After transferring the tracings to paper, tangents originating in the retruded position were drawn to the curves. The angle thus formed with the base line of the glass plate was measured, and the variation of the resulting angles was calculated.

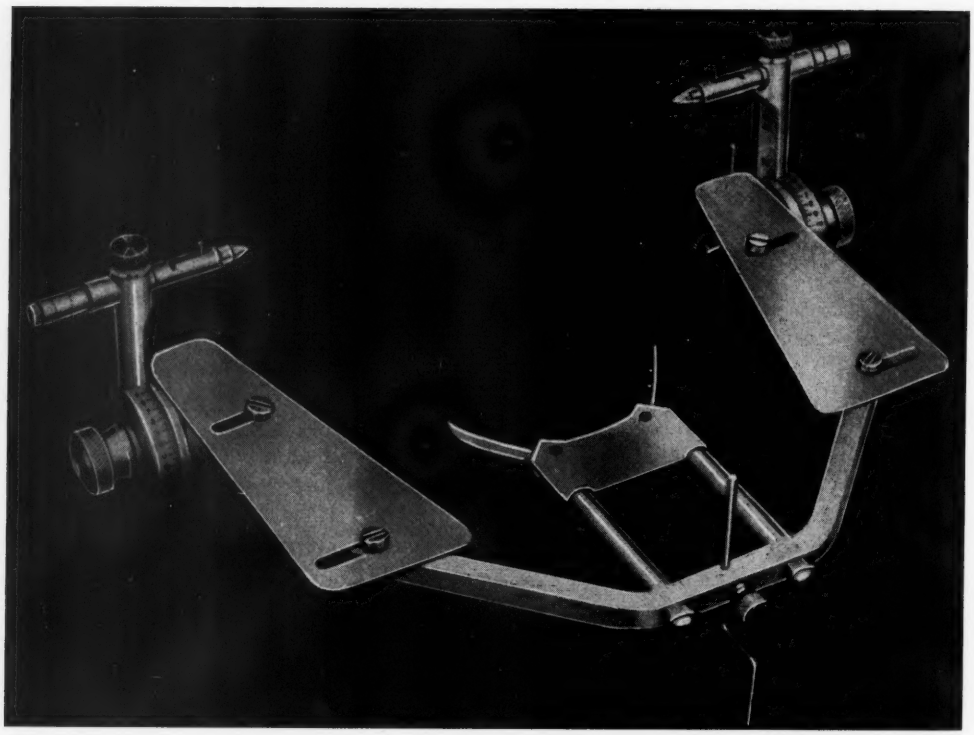

Fig. 1.—The Gysi face-bow.

In order to evaluate the error of transferring the tracings from the glass plate to paper, five more graphic registrations on each side of the mouth of the same person were used. The registrations made on 2 successive days were traced on paper and the tangents were drawn. The average error between the tracings was 3.8 degrees.

The first five values were selected for statistical evaluation. They were treated in a similar manner as the values obtained when using wax records.[1]

RESULTS

The values have been arranged in Table I to compare them with the corresponding values obtained from the wax record method. The over-all average for the wax record method, with the elimination of 2 mm. of protrusion[1] (involved during the wax record method), was 2.3 for the error of the single observation and 17.9 for the sensitivity. The corresponding values from the graphic method were 5.4 and 25.7.

The values for the sensitivity cannot be compared directly, because they were calculated from different groups of patients by different examiners. However, the error is about twice as large in the graphic method as compared with the intraoral wax record method. The tests suggest that the graphic method is much less reliable than the wax method.

The drawing of a tangent to the recorded condyle path curve, starting from the retruded position, was the most precarious part of the graphic method. Therefore, the drawing error is probably associated with the largest error.

DISCUSSION

The curved condylar path can be recorded graphically with specially designed instruments, and these graphic tracings are reproducible.[8-10] The fixation of the tracing papers or plates during the tracing is a source of error in the Gysi technique, but this has been overcome in the McCollum technique.[9] Graphic records of border movements for patients with normal dentitions can be transferred to a Gnathoscope with a high degree of exactness by using a special, adjustable instrument.

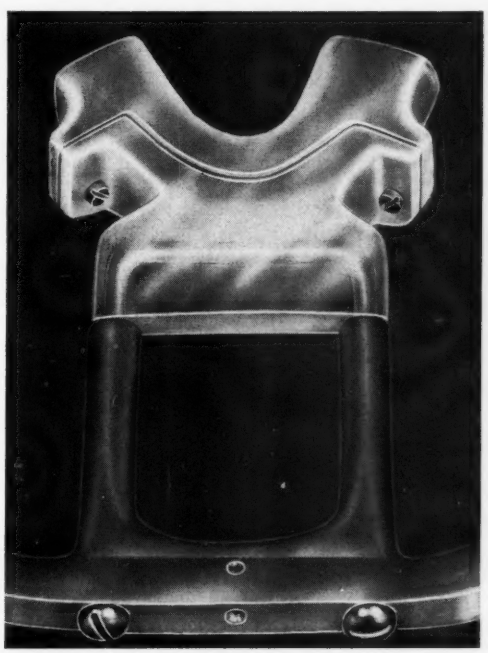

Fig. 2.—An acrylic resin tray was used to fix the face-bow to the lower dental arch.

According to the Gysi technique, the "straight part of each condyle path tracing" is extended upward and downward by the use of a straightedge. The cards are cut along the extended lines of the condyle path tracings, and this oblique edge is used to adjust the condyle path inclinations of the Trubyte articulator.[3,4] This

TABLE I. CONDYLE PATH INCLINATIONS OF 10 PERSONS, DETERMINED BY INTRAORAL WAX RECORDS[1] AND BY THE GRAPHIC METHOD

METHOD	MEANS	STANDARD DEVIATION	
		ERROR	SENSITIVITY
Wax records on the Dentatus articulator.[1] Over-all average for 4, 6, and 8 mm. protrusion	30.3	2.3	17.9
Graphic records. NB: The sensitivity is only valid for various condyle path inclinations	36.3	5.4	25.7

method is not used extensively in its original form. The technique probably contains further sources of error when the angle is transferred to the condylar mechanism of the Trubyte articulator. These latter errors have not been assessed in the present investigation.

Narbe and Årstad[11] compared the intraoral wax record method with the Gysi graphic method. Since they made the experiments using complete denture subjects and used a central bearing point, the results cannot be compared with those of this study. Moreover, they did not indicate the variation of the results obtained with the Gysi method.

Ekensten[12] assessed the degree of occlusal balance obtained in complete dentures by a mean-value articulator, a Gysi Trubyte articulator, and a Brandrup-Wognsen articulator.[13] He concluded that dentures made by the Brandrup-Wognsen technique had a better balanced occlusion than dentures made by the Gysi Trubyte technique. This conclusion, apart from stemming from complete dentures, comprises the total of a large number of details and, therefore, cannot be compared directly with the results from the present investigation, which is much more limited in scope.

SUMMARY

The variation of the condyle path inclination, as recorded graphically and constructed according to the Gysi technique, was examined on 10 young subjects. Five registrations and constructions for each subject were analyzed statistically.

The error of the graphic method was found to be about twice that of the intraoral wax method. It is probable that the error is mainly caused by the difficulty in drawing a tangent to the curved condylar path rather than to the recording itself.

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THE HINGE AXIS AND ITS PRACTICAL APPLICATION IN THE DETERMINATION OF CENTRIC RELATION

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THE DENTAL PROFESSION recognizes the importance of an understanding of centric relation. It is aware of the discomfort, pain, and illness that can result from the improper utilization of centric relation. It knows the comfort, absence of pain, good function, and health of the masticatory apparatus and person that can result from the proper practical application of the truths of this relationship.

Unfortunately, dentists often think in terms of technique rather than basic science. In order to develop a satisfactory technique, it is necessary to have a complete knowledge of the parts with which we are concerned. A thorough understanding of the basic sciences involved is of prime importance.

What is centric relation? Why is it so important, and why should we be so concerned with it? What are the benefits to be derived by a patient when the occlusion is in harmony with centric relation, and what are the ill effects when this harmony does not exist? These are the questions I hope to answer.

HISTOLOGY

All living tissue consists of cells. A requisite for a healthy cell is that it be in function. By the same token, if a cell is overworked or traumatized it will die.

Because of the manner in which a tooth is surrounded by periodontal fibers (Fig. 1), the stress on that tooth can best be borne in a vertical direction. A horizontal force causes strain on only some of the fibers. A vertical force divides the pressure equally over a much larger surface and thus the teeth will be supported by many fibers. An eccentric mandibular relation causes lateral stress on the teeth throughout the entire mouth.

We are all familiar with the classic roentgenogram of a lower second molar that has drifted forward into the space left vacant by a nonreplaced extracted first molar (Fig. 2).

The lateral component of force causes a deep mesiogingival pocket with a subsequent breakdown of alveolar bone. The lateral force is transmitted mainly to the gingival third of the mesial root on its mesial surface. This lateral component of force is manifest on all the teeth throughout the mouth when the mandible is in an eccentric relationship to the maxillae in the final closure of the teeth (centric occlusion). In a dentulous patient who closes in an eccentric position, we see

Read before the American Academy of Crown and Bridge Prosthodontics, Chicago, Ill.

evidence of generalized periodontoclasia. In a patient with complete dentures, the result is unstable bases, and no amount of trimming of the bases will eliminate sore spots on the gums.

ANATOMY OF THE TEMPOROMANDIBULAR JOINT

The temporomandibular joint consists of the condyle, the glenoid fossa of the temporal bone, the meniscus, the ligaments, and the muscles of mastication which hold the joint together. The blood vessels and nerves which supply these structures also are present.

Fig. 1

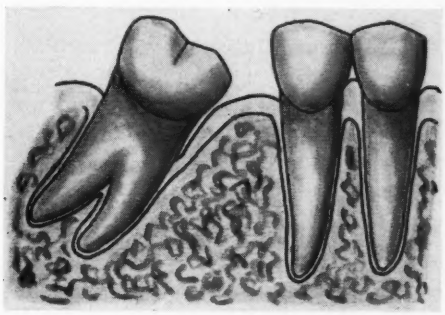


Fig. 2

Fig. 1.—A cross section through the periodontal ligament shows the direction of its fibers and the manner in which the normal tooth is supported and cradled.

Fig. 2.—The alveolar bone on the mesiogingival third of a second molar has broken down. The tooth has drifted forward into the space formerly occupied by a first molar. This shows that lateral force is destructive to alveolar bone.

The muscles of mastication are the masseter, temporalis, and the internal and external pterygoids. They supply the dynamic force which raises the mandible and moves it forward, backward, to the right, and to the left. The mandible is depressed by the genihyoid and mylohyoid muscles and the anterior belly of the digastric muscle. The capsular, temporomandibular, stylohyoid, stylomandibular, and sphenomandibular ligaments assist in holding the joints in position.

PHYSIOLOGY OF TEMPOROMANDIBULAR JOINT

The range of movement of the mandible is entirely dependent upon the anatomy of the temporomandibular joint, the muscles of mastication, and the depressor muscles of the mandible. The paths of movement of the condyles are fixed and cannot be altered.[1] The muscles of mastication, except for the external pterygoid muscles, carry the condyles upward and backward.

The temporomandibular joint is a ginglymoarthrodial joint, or a gliding hinge, and is the only joint of this type in the human body. Realistically, the temporomandibular joint is not one, but two joints separated by the meniscus. The gliding movement takes place above the meniscus. The superior surface of the meniscus moves along the anterior wall of the glenoid fossa (protrusive path) and the inner

curbing of the glenoid fossa (Bennett movement). The latter movements are controlled mainly by the external pterygoid muscles.

The part of the joint inferior to the meniscus is capable of a hinge movement. The meniscus is constant to the center of rotation of the condyle so that while the condyle moves forward, backward, or sideways, the meniscus moves along with it.[2]

An opening and closing movement of the mandible is always a combination of the gliding and hinge factors. This has led to great confusion in understanding the dynamics of the mandible. There is only one position where the condyle can rotate in a pure hinge movement, i.e., when the condyle is as far as it can go by its own muscular power into the glenoid fossa. This is a trained movement and is used in the determination of centric relation.

IMPORTANCE OF CENTRIC RELATION

A patient cannot chew in centric relation. Therefore, why are we so concerned with it? When a bolus of food is prepared for swallowing, the teeth attempt to macerate the bolus so that it has a semifluid consistency as it passes into the esophagus. To do this, it is necessary to apply strong muscular force against the bolus. At this time, the condyles follow the paths of movement that the anatomic structure of the joint dictate, i.e., in an upward and backward direction. The condyle tries to seat itself in the glenoid fossa as far as it will go by its own muscular power. If the teeth intervene before this position is reached, however, there is a lateral component of force registered upon the teeth. The degree of this lateral force is directly proportional to (1) the amount of force applied by the muscles of mastication and (2) the degree the jaw is out of centric relation. At times the eccentric relation of the condyles in the glenoid fossa causes pressure on the border of the meniscus which results in severe pain in the region of the temporomandibular joint. The center of the meniscus is devoid of blood vessels and nerves and is pressure bearing. The border of the meniscus contains blood vessels and nerves, and pressure on these edges causes pain.

Muscular spasm may be another result of this eccentric condylar position. In the final phase of chewing, before swallowing, the condyle will try to seat itself in the glenoid fossa. If this position cannot be reached, the proprioceptors in the periodontal membrane send stimuli to the temporomandibular joint to accommodate this eccentricity. The joint then sends stimuli to the motor mechanism (muscles of mastication) to meet this situation. However, there may be other painful stimuli set up in the temporomandibular joint. If there is pressure on the border of the meniscus in this same position, the temporomandibular joint will send additional stimuli to the muscles. The excessive stimulation of the muscles throws them into painful spasm.

The question is often asked, "Why is it that not all patients whose centric occlusion and centric relation are inharmonious are not heir to all the pathologic changes attributed to this condition?" There are several reasons. There may be a degree of tolerance in the joint which permits the condyle to be out of its ideal position in final closure of the mandible. There are, from a morphologic viewpoint, three types of glenoid fossae (Fig. 3).

Type I.—The anterior slope of the fossa is very light and, although the condyle may not be seated as far back as it can go in final closure, there will not be a great lateral component of force on the teeth or a pressure on the border of the meniscus. However, the ideal position of the condyle in final closure is that in which it is completely seated in the gleonoid fossa. This type of joint has the greatest degree of tolerance.

Type II.—This type of glenoid fossa is the one most generally encountered. The anterior wall has approximately a 30-degree inclination to the axis-orbital plane. This joint has little tolerance.

Type III.—This type of glenoid fossa is found occasionally. It has a very steep anterior wall and has no tolerance. This type of joint causes the most trouble since any slight eccentricity of the maxillomandibular relationship causes a pressure on the borders of the meniscus. If the condyle is not seated in the fossa in final closure, it can result in a strong lateral strain on the teeth.

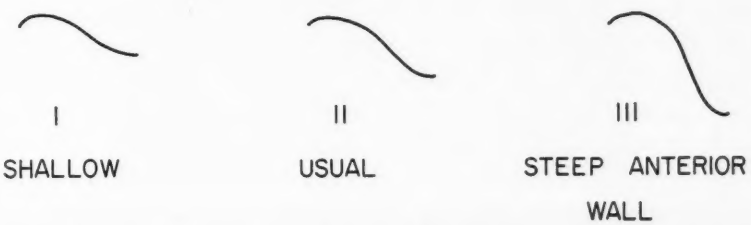


Fig. 3.—The glenoid fossae are classified according to the morphology of the anterior wall of the fossa.

Another reason that some individuals do not show pathologic changes although they have a malocclusion in centric relation is that they possess an exceptionally high degree of physical well-being. The chemical balance (endocrine balance, bone factor, calcium-phosphorus ratio, etc.) is excellent, all of the organs are healthy and function well, and they are well-adjusted individuals.

LOCATING THE HINGE AXIS

The first part of the procedure consists of locating and permanently recording the center of rotation of the mandible when the condyles are seated in the glenoid fossa as far as they will go by their own muscular power. It is neither a retruded position, nor a forced position. The patient must be trained to open and close the mouth in this position. I have devised an instrument to do this called the "hinge axis trainer." It is a variation of the Hickock chinstrap apparatus.

Prior to the application of the hinge axis trainer (Fig. 4), a cast aluminum clutch with a stud is cemented temporarily to the mandibular teeth with zinc oxide and eugenol impression paste. The Granger or Lauritzen chinclamp can be used instead of the mandibular clutch for the edentulous patient. Very little pressure is applied to the chinstrap. The patient is instructed to open and close the mouth about an inch[3] with the trainer in position, and the movements are repeated for a period of about 10 minutes. Patients attempt to move the mandible protrusively

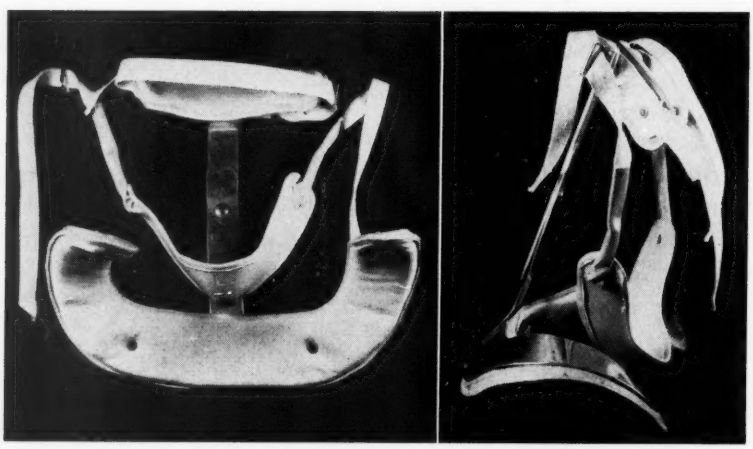
for about 5 minutes, after which there are smooth opening and closing in pure hinge movements, i.e., the condyles go up and back into the glenoid fossae. After 5 more minutes, the patient is trained properly to open and close the mouth in the terminal hinge position, and the trainer is removed.

A face-bow is attached to the stud of the maxillary clutch. This face-bow has, at each terminus opposite the tragus, a flag covered with graph paper which is used for convenience in locating the hinge. Another face-bow with an adjustable stylus opposite each graph paper flag is attached to the mandibular clutch (Fig. 5).

We are now ready to locate the hinge axis. This is done by determining the center of rotation of the mandible on each side of the face. An imaginary line drawn through these two points is the hinge axis.

The dentist places a slight downward pressure with the thumb against the chin of the patient while the patient opens and closes the mouth no more than an inch. By this process the closing muscles of mastication will carry the condyles into the glenoid fossae as far as they will go by the power of the muscles.

By close observation of the arc scribed by the stylus, an adjustment is made to approach the center of rotation. The nature of the adjustment is determined by (1) the direction of the arc and (2) the size of the arc. We use the geometric principle that if a secant intersects an arc of a circle, its perpendicular bisector will coincide with the radius of the circle.



A. *B.*

Fig. 4.—The hinge axis trainer. *A*, The front view. *B*, The side view.

The larger the arc scribed by the stylus, the farther the stylus is from the center of roation, and therefore the greater the adjustment necessary. The direction of the adjustment depends upon the direction of the arc (Fig. 6). In order to facilitate the location of the hinge axis a magnifying glass or binocular loupe should be used. The stylus opposite one condyle is adjusted to a spot where the point will not arc when the patient opens and closes. The same procedure is followed on the opposite side.

With the patient's head away from the headrest so that the skin of the face is not stretched, the points representing the location of the hinge axis are marked permanently on each side of the face with pink tattoo ink. A third point also is marked on the nose opposite the infraorbital notch. While the hinge axis is all that is necessary for locating centric relation, the axis-orbital plane must be used for reference in the transfer of casts to the articulator if articulation that conforms with the individual condylar paths of movement is to be developed.

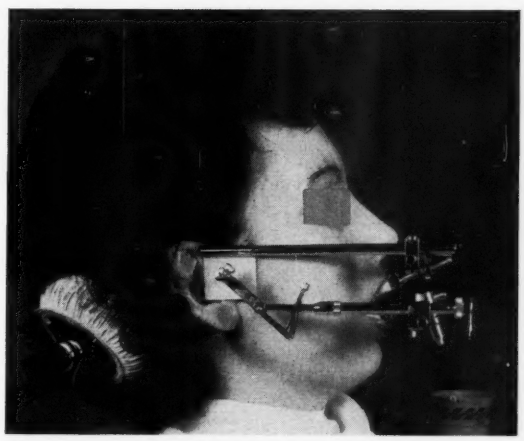


Fig. 5.—Graph paper is attached to the upper stud and an adjustable stylus is attached to the mandibular stud for locating the hingle axis.

A correct centric relation will solve many problems. The dentist should go further in his treatment, however, especially with the problem patient. The individual condylar paths of movement must be reproduced on an instrument to develop equal and simultaneous contacts of all the teeth in every excursion of the mandible.

ADVANTAGES OF LOCATION OF THE HINGE AXIS

Once the hinge axis points have been located and marked permanently on a patient, it is never necessary to repeat the procedure since the anatomic structures they represent never change during life.

It is now possible to mount casts on an instrument with a hinge and take advantage of the benefits derived from the record. These are:

1. Study casts may be mounted to determine if the patient's centric occlusion is in harmony with centric relation.
2. Working casts can be mounted in the best relationship for the teeth or the denture bases.
3. Since the hinge is a definite fixed component of every closing position of the mandible, it is necessary to reproduce it on the appropriate instrument if the occlusion is to be rehabilitated.
4. It is possible to increase or decrease the vertical dimension on the instrument without disturbing centric relation.

MOUNTING THE CASTS

Face-bow Registration.—A wafer of red modeling compound* is softened in a water bath at 135° F. The compound is placed on the rim of a face-bow fork and shaped to the approximate contour of the upper dentulous arch. The compound-covered fork is placed against the maxillary teeth without permitting the teeth to penetrate the compound. The stud of the face-bow fork should be in the region of the upper left central incisor. The patient is directed to close the mandibular teeth lightly into the inferior surface of the modeling compound to hold the fork firmly in position while the face-bow is attached to the stud.

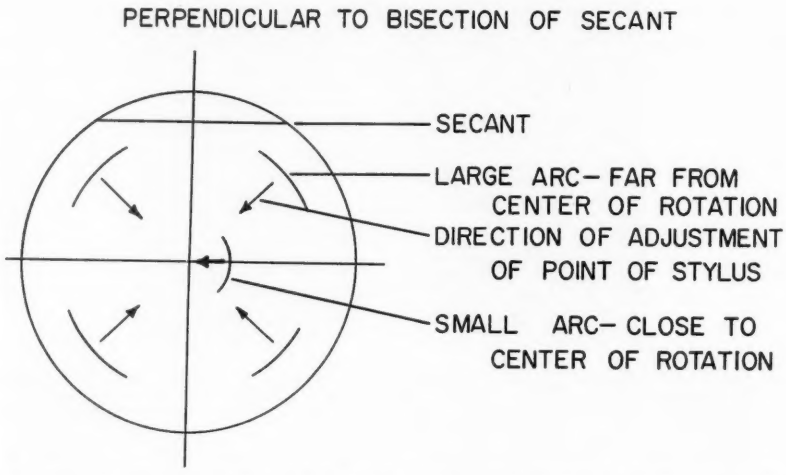

PERPENDICULAR TO BISECTION OF SECANT
SECANT
LARGE ARC– FAR FROM CENTER OF ROTATION
DIRECTION OF ADJUSTMENT OF POINT OF STYLUS
SMALL ARC– CLOSE TO CENTER OF ROTATION

Fig. 6.—The adjustment of the stylus depends upon the direction of the arc scribed when the patient opens and closes the jaw in the terminal hinge position.

For the edentulous patient, a modeling-compound occlusion rim is attached to a shellac baseplate or a metal base (for the finished denture) fitted to the upper dental arch. Then, the fork is imbedded into the modeling compound.

The face-bow is attached to the stud of the face-bow fork. With the patient's head away from the headrest, the points of the stylus are adjusted to touch the tattoo marks opposite the condyles. Anteriorly, the infraorbital indicator is placed to coincide with the tattoo mark on the nose. The face-bow is removed carefully.

The hinge axis trainer is placed on the patient and he is instructed to open and close the mouth about an inch without permitting the teeth to meet. This is done for 10 minutes to train the patient to open and close the jaw in the terminal hinge position. Then the hinge axis trainer is removed.

Centric Relation Record.—Wax wafers are prepared prior to the patient's appointment. Each wafer consists of three layers of S. S. White Tenax wax with a center strip of Moyco Alcezon Wax (Fig. 7).

No other preliminary preparation is necessary for a dentulous patient. However, it is necessary to prepare wax or compound occlusion rims prior to the regis-

*Kerr Dental Manufacturing Co., Detroit, Mich.

tration of centric relation for edentulous patients and sometimes for partially edentulous patients. The occlusion rims are made so that the mandible is in approximately the correct vertical and centric relation to the maxillae. The final registration of centric relation is made with the preformed wax wafers. If the discrepancy between centric occlusion and centric relation is not great, one wafer is used. If a major discrepancy exists, two wafers are used.

The wafers are softened thoroughly in a water bath at 118° F. The patient opens and closes the mouth while a slight downward and backward pressure is placed on the chin by the dentist. The wax is placed in the patient's mouth, and the

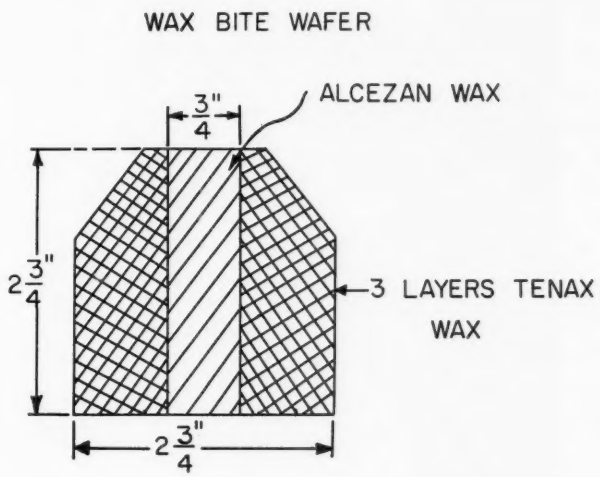


Fig. 7.—A wax wafer is used to register centric relation.

patient closes in the terminal hinge position into the wax without biting through it. The slight downward and backward pressure is maintained on the chin. It is extremely important that both condyles are in their terminal hinge position when the centric relation record is made.

After about 1 minute, the wax is removed and placed in a container of room-temperature water. If this water is too cold it may warp the wax. After several minutes, the wax is removed from the water and returned to the patient's mouth to make certain that the correct centric relation was recorded. The wax registration is again placed in the room-temperature water bath and set aside for the laboratory phase of the work.

LABORATORY PHASE

An articulator is used which contains (1) a hinge and an indicator for its hinge and (2) an adjustment so that the hinge indicator can be moved toward or away from the midline. Several instruments can be used, e.g., some models of the Hanau articulator, the Granger Gnatholator, the Stuart instrument, the Dentatus articulator, and the McCollum Gnathoscope.

Fig. 8

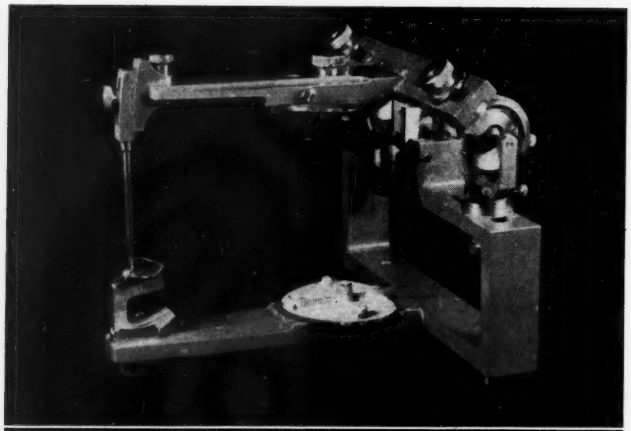


Fig. 9

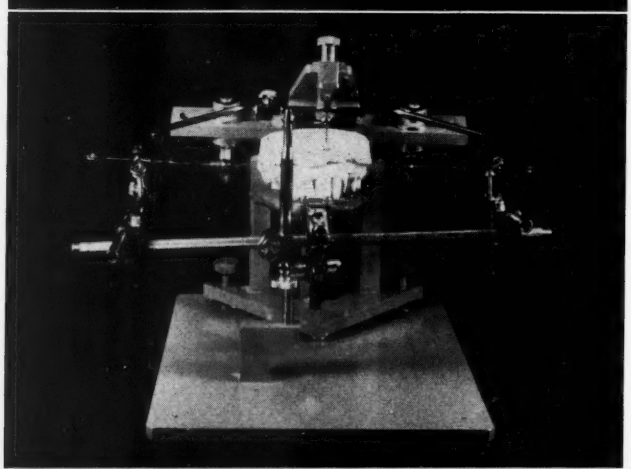


Fig. 10

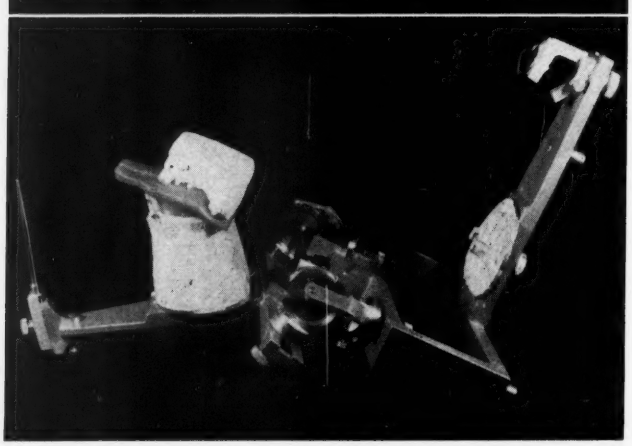


Fig. 8.—The McCollum Gnathoscope.

Fig. 9.—The upper cast is mounted on the Gnathoscope so that the hinge and axis-orbital plane of the patient correspond to the similar parts of the instrument.

Fig. 10.—The lower cast is seated in the centric relation record.

I prefer the McCollum Gnathoscope. It is a completely adjustable instrument that reproduces the hinge axis and all other mandibular movements (Fig. 8). The Granger and Stuart instruments also fall into this category. The other instruments mentioned can reproduce the hinge, but are not sufficiently adjustable to reproduce all mandibular movements.

PROCEDURE

The face-bow is held in position by means of a special mounting jig (Fig. 9). The hinge axis of the articulator is adjusted to coincide with the points of the styluses, which represent the hinge axis of the patient. The maxillary cast is seated firmly in the modeling compound on the face-bow fork.

By means of quick-setting stone, the maxillary cast is attached to the upper member of the Gnathoscope so that the axis-orbital indicator on the face-bow coincides with the equivalent of the axis-orbital plane of the instrument. The stone should have a setting expansion of not more than 0.05 per cent (Grey Rock or Trustone). A small quantity of Terra Alba added to the stone hastens the setting time.

After the stone has set thoroughly and the excess has been removed, the wax wafer recording is seated on the upper cast (Fig. 10). The lower cast is seated firmly on the opposite side of the wax wafer registration, and by means of quick-setting stone the lower cast is attached to the lower member of the Gnathoscope.

After the stone has set completely and the wax is removed, the casts are mounted in the correct centric relationship and can be used for purposes of diagnosis or treatment.

CONCLUSIONS

1. The most important maxillomandibular relationship to record is centric relation.

2. A knowledge of the basic sciences is necessary for a proper understanding of centric relation.

3. By utilizing knowledge of the basic sciences, casts can be mounted in proper centric relation on an instrument.

4. Many dental problems can be completely or partially resolved by restoring harmony between centric occlusion and centric relation. A dentulous patient will maintain healthy alveolar bone, and denture bases will be stable for edentulous patients. Many pathologic temporomandibular joints will become healthy.

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RECORDING THE VERTICAL DIMENSION OF OCCLUSION

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The vertical dimension of occlusion is the vertical relation of the residual ridges or the measurement of the face when the occlusal surfaces of the teeth or the occlusion rims are in contact. If an individual has a good occlusal relationship between the upper and lower dentitions, the occlusal contact of the teeth will be the most comfortable position for deglutition.

The act of swallowing is a normal physiologic reaction that is performed involuntarily many times each day. The muscles that control deglutition, however, can and do respond to the will of the individual. The coordination of the muscles that place the mandible in the most comfortable position for swallowing is the same after the teeth have been lost as it was when they were present, provided the individual is given an uninhibited opportunity. Some inhibiting factors to normal swallowing are (1) loss of the upper dentition, (2) premature contact of occlusion rims, and (3) mental or physical interferences.

When given the proper conditions, any normal patient will quickly determine the mandibular relation that will (1) be most comfortable during deglutition, (2) be most functional for all masticatory movements, (3) be most effective in establishing esthetic appearance, and (4) be the least likely to hasten the destruction of the residual ridges.

Four conditions must be present for the edentulous patient in order to determine the correct vertical dimension of occlusion. There must be (1) a baseplate with an occlusion rim that approximates the normal palatal form, since the anterior third of the tongue must have lateral contact in the bicuspid region of the palate during comfortable deglutition, (2) no interfering contacts of the occlusion rim, (3) no mental or physical interference from the dentist, and (4) a material that will in no way interfere with the movement of the mandible but that will quickly record the position in which the swallowing act was completed.

PROCEDURE

Baseplates and occlusion rims are constructed and contoured so that the palatal surface of the upper occlusion rim is the same shape as that part of the denture and so that the rim is in approximately the same position that the teeth will occupy. The mandibular occlusion rim must be short of the correct vertical dimension of occlusion.

A small cone of a very soft wax (Iowa Formula) is placed on the lower occlusion rim in the second bicuspid and first molar areas. The cone is about 5 mm.

high with a base of less than 5 mm. The patient is seated in an upright position free of the headrest. He is instructed to open the mouth so that the dentist can see the wax cones. Next he is asked to swallow and then reopen his mouth.

During the swallowing act, the movement of the patient's Adam's apple is important. If the excursion of the thyroid cartilage is an uninterrupted upward movement and a return to normal, the cone of soft wax will contact the upper occlusion rim and indicate the exact distance between the upper and lower residual ridges for the correct vertical dimension of occlusion. If there is a slight interruption of the upward movement of the thyroid cartilage, either there is a contact of the occlusion rims *with displacement* of the cones of soft wax or there is no contact of the soft wax against the upper occlusion rim during the swallowing act. The coordinated muscular action during the swallowing movements is very sensitive to the slightest nonobstructing contact but will not tolerate interference.

All interocclusal centric and eccentric registrations are made at the distance registered between the maxillary and mandibular residual ridges. The swallowing act with the soft wax cones may be used as a check for any oral condition when a reduction of the interarch distance is suspected.

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A POSTERIOR TOOTH COMBINATION

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THE INTERARCH DISTANCE of edentulous patients is often great anteriorly but too small posteriorly. This is frequently true in patients who have a "flat" lower ridge. Generalized ridge resorption and esthetic requirements indicate the use of a long anterior tooth, yet the small interarch distance in the second molar region dictates the use of a short posterior tooth. Such a tooth combination results in poor appearance, particularly when the patient smiles (Figs. 1 and 2).

POSTERIOR TOOTH COMBINATION

A solution to this problem is the use of a combination set of posterior teeth made up from three to six different molds. The premolars may be selected from a set of *long* posterior teeth, the first molars from *medium* teeth, and the second molars from *short* teeth. The appearance is enhanced greatly by such a combination of teeth (Figs. 3 and 4).

ADVANTAGES AND DISADVANTAGES

There are other advantages to this selection of posterior teeth. Excessive grinding and weakening of the second and first molars are avoided, and less time is required in their arrangement. The upper second molars can be made as short as possible, permitting the plane of occlusion to be most advantageously placed.[1]

The disadvantages are obvious. Extra teeth must be purchased, because one's supply of odd, long premolars and short molars is soon exhausted. In a short while, there is a great accumulation of short premolars and long molars which is expensive but useless.

POSSIBLE SOLUTIONS

The problem would be solved if the manufacturers and distributors of denture teeth would authorize the exchange or return of broken sets of posterior teeth as they do with anterior teeth.

Another solution would be a "combination" set of posterior teeth composed of long premolars, medium first molars, and short second molars. Such a set of teeth could be designated by the letter *C* for combination, similarly to the *S* for short, *M* for medium, and *L* for long of standard sets.

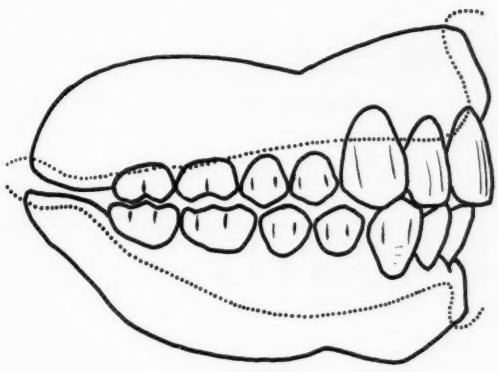

Fig. 1

Fig. 2

Fig. 1.—When the interarch distance is large in the anterior and small in the posterior regions, long incisors and short molars are indicated. If short premolars are used, the esthetic effect is poor.

Fig. 2.—When the patient smiles, the excessive exposure of the denture base in the premolar region is unnatural.

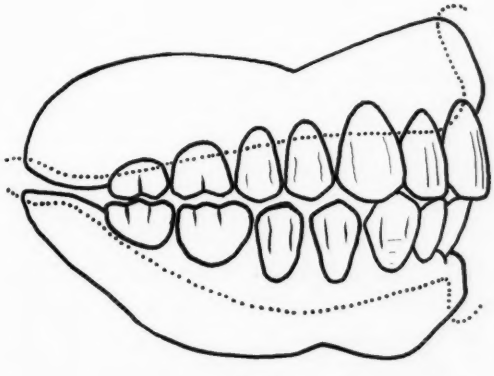

Fig. 3

Fig. 4

Fig. 3.—Denture esthetics can be improved greatly by using premolars from a *long* mold, first molars from a *medium* mold, and second molars from a *short* mold.

Fig. 4.—The unnatural discrepancy between the lengths of the anterior and posterior teeth has been eliminated and an excessive amount of denture-base material is not displayed.

Tooth manufacturers, dental supply companies, and commercial dental laboratories would find this innovation an advertising attraction and an inexpensive advantage.

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TROUBLE SHOOTING IN COMPLETE DENTURE PROSTHESIS
Part III. Traumatic Injuries*

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NEUROMUSCULAR TRAUMATIC INJURIES have been given little attention in dental literature. They are important etiological factors in mucosal disorders.

Certain neurotic persons with severe aggressive drives frequently find an outlet for their nervous tensions in grinding, gnashing, and biting forcefully with their dentures. This is most common in men with neurotic backgrounds who live in environmental conditions charged with high emotional strains and stresses.

BRUXISM

Neuromuscular traumatic injuries should not be identified with bruxism. While the two have some features in common, they differ in many respects. Bruxism with natural teeth is frequently a local manifestation of a general condition. It is an expression of nervous tension and conscious and unconscious aggressive tendencies while awake as well as asleep. Grinding, gnashing, and biting forcefully with dentures also may be due to a deep-seated neurosis, but frequently is attributable to the dentures themselves. Malocclusion in centric and eccentric positions of newly constructed dentures may lead to the habit of grinding and gnashing.

It is essential to establish whether the primary cause of bruxism is habit formation or a deep-seated psychoneurosis. Where habit formation is the etiological factor, a careful study should establish how the habit was formed. There are circumstances in which the patient was never afflicted by this syndrome until after wearing dentures. It may be an attempt by the patient to remove occlusal interference by grinding it away. Soon, however, this grinding or gnashing of the dentures causes trauma to the supporting structures. Pain results and becomes the cause for further intensification of bruxism. The patient now grinds and clamps his teeth in order to rid himself of the pain caused initially by the grinding itself. In this way, bruxism becomes a vicious circle which is progressive and self-perpetuating. In other instances poor retention is the cause, and the patient uses pressure to make the dentures stay in place. Mouth rehabilitation and the establishment of a balanced occlusion followed by psychotherapeutic procedures are prime requisites in an endeavor to break this harmful habit.

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EXCESSIVE MUSCULAR FORCE

Occlusal interferences in centric and eccentric positions are largely remediable. The most troublesome denture adjustments are those in which the magnitude of forces of the patient's muscles is out of proportion to the tolerance of the oral mucosa. There can be no control over the forces that the patient's muscles of mastication exert upon the dentures. One has only to visualize a patient whose natural teeth have undergone considerable attrition. Whether this attrition is neuromuscular in origin (when the patient is emotionally involved) or physiomuscular (when there is application of excessively strong, natural muscular forces during mastication), the destructive effect upon the tooth substance or periodontal structures or both is severe. When such patients wear complete dentures and by force of habit continue to exert the same type of muscular forces, the denture supporting structures must deteriorate sooner or later. This is exactly what takes place unless the patient is guided properly by the dentist.

TREATMENT

This type of traumatic injury requires special treatment.

1. The highest type of balanced occlusion must be attained.
2. The buccolingual diameter of the posterior teeth should be as narrow as possible.
3. The vertical dimension of occlusion is reduced, below what would otherwise be considered normal, for severe problems.
4. Mucosal irritations are relieved as soon as they appear. The mucosa of the entire lower ridge is usually inflamed and congested, but painful spots arise over sharp bony projections of the alveolar process. When the blood circulation in the mucosa is deranged, there is an adverse effect upon the circulation in the periosteum. This eventually leads to poor nutrition in the bony supporting structures, with the formation of sharp points. Rebasing lower dentures for physiologic adaptation is helpful in relieving the pressure upon these sharp points and thereby reducing the pain and discomfort to the patient.
5. Removing the dentures from the mouth for an hour or so affords the tissues a rest and gives some relief to the patient.
6. Constructing two lower dentures to the same upper denture permits frequent interchange of the dentures. The second denture should be made from a new impression and a new centric relation record, otherwise it is of limited benefit.
7. The sharp bony projections in the lower anterior segment of the ridge should be relieved with tin foil in accordance with a definitely established procedure.
8. The patient may be advised to suck on diabetic candy as a decoy against grinding his teeth.
9. Psychotherapy may be instituted to improve the patient's emotional status.
10. Tincture of Merthiolate (1:1000) is prescribed for painting the irritated mucosa in order to afford temporary relief from pain.

TRAUMATIC INJURIES CAUSED BY TRAUMATIC OCCLUSIONS

A definite concept of traumatic occlusion is a prerequisite to any discussion of the injuries it causes. In a study of the reaction of oral mucosa under complete dentures, it is necessary to differentiate two types of traumatic occlusion.

1. That with which the changes in the mucosa progress so slowly and are so innocuous that a physiologic readaptation after a certain period of time is the rule. This type is designated as a *physiologic pattern of traumatic occlusion.*

2. That with which the changes of the mucosa are so rapid and so severe that physiologic readaptation is impossible. This type is designated as a *pathologic pattern of traumatic occlusion.*

The physiologic pattern of traumatic occlusion is harmless and, in most instances, useful. If the dentures are properly constructed and well balanced from every standpoint, the masticatory mucosa (the basal seat of the dentures) develops new positive qualities. These qualities are acquired by the mucosa under the uniform intermittent masticatory pressure to which it is subjected. This applies to all other nonmasticatory pressures exerted by well-balanced occlusions. Clinically, many newly constructed dentures that give rise to hypersensitivity of the masticatory mucosa are observed. Gradually, however, this high sensitivity is replaced by a marked tolerance of the mucosa to the foreign bodies—the dentures—without any significant therapeutic intervention. This suggests that the mucosa develops nerve tolerance qualities under new environmental conditions.

A logical argument may be advanced at this point. If the supporting structures develop new resistance qualities under the impact of dentures with well-balanced occlusions, why then is resorption of these structures observed as the years go on? The answer is that perhaps the mucosa and osseous structures of the alveolar ridges undergo greater resorption in individuals who do not wear dentures at all. Some resorption of the alveolar ridges under dentures is, therefore, to be expected and accepted as physiologic.

We can utilize the physiologic pattern of traumatic occlusion to advantage during the period of the patient's adjustment to new dentures. The average patient with upper and lower complete dentures goes through three successive stages.

The first stage is a trying one. The patient is becoming acquainted with his newly inserted dentures by the sensations he experiences. These experiences are not pleasant, and the patient has a great deal of discomfort and pain, both *dental and mental.* He may become psychologically conditioned and obsessed with the idea that the dentures will never fit. Having arrived at this decision, the patient can no longer be expected to be cooperative and make a smooth transition into the second stage.

The second stage is one in which the patient's pain is considerably less. The dentures are more firmly adapted to the supporting structures, the pain threshold rises, and the tolerance of the mucosa is augmented. The patient feels more at ease physically and mentally and is on the way to complete adjustment to the dentures. The reflexes controlling the functional relationship of the dentures become well organized. Psychologically, the patient has a feeling of a great degree of security.

The third stage is the one in which the patient is becoming less and less aware of being a denture wearer. The dentures become a part of himself.

We can see how important the first stage is in the process of becoming adjusted to dentures. The first stage is the decisive one for the patient both physically and mentally. The doctor-patient relationship should be one of utmost confidence and mutual cooperation. The patient should be seen as frequently as necessary to keep the pain under control. Meanwhile, the mucosa under the dentures builds up more and more tolerance through the physiologic pattern of traumatic occlusion.

When complete dentures are balanced for vertical equilibrium as well as for horizontal movements, therefore, the benefit to the supporting structures is twofold. First, the mucosa is protected by the denture from being injured by hard,

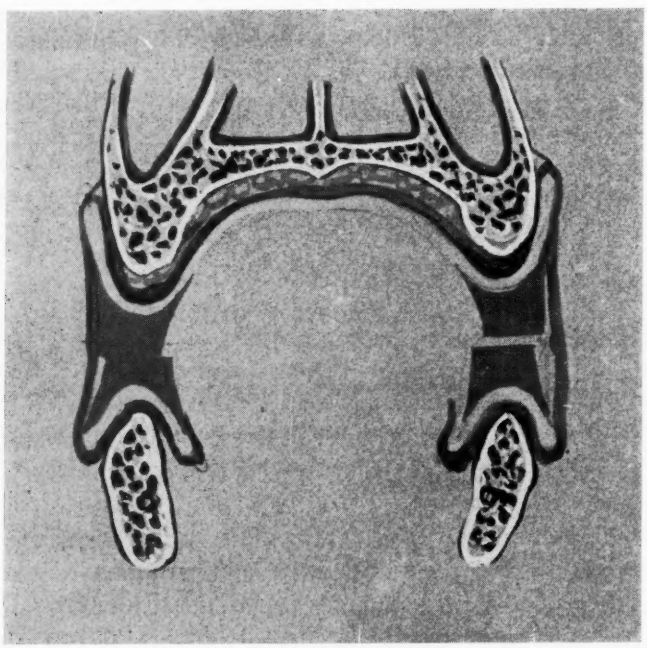

Fig. 1.—Failure in equilibration of vertical contact. A lack of vertical equilibrium during the recording of centric relation results in this same condition between the upper and lower teeth in the completed denture. Redrawn after R. H. Kingery.[2]

rough, and sharp food particles that would otherwise come in direct contact with the mucosa. Second, the physiologic pattern of trauma to which the supporting structures are subjected by a well-balanced occlusion is becoming a source of physiologic stimulation to the underlying mucosa. The development of the muscles of the blacksmith's arm through excessive use is an analogy to this type of physiologic trauma, as are the various types of massage that consist of kneading, rubbing, pressing, slapping, and vibrating the various parts of the body. This is trauma that is beneficial rather than injurious. Similarly, well-balanced complete dentures have,

to a certain extent, a massaging effect upon the underlying mucosa. This is one of the many mechanisms by which the mucosa develops tolerance during the first 3 to 4 weeks (first stage) of wearing new dentures.

The newly inserted dentures act like a foreign body in the oral cavity and represent a great hindrance in mastication, deglutition, and speech production. These problems are more complicated than they seem at first. The dentist must

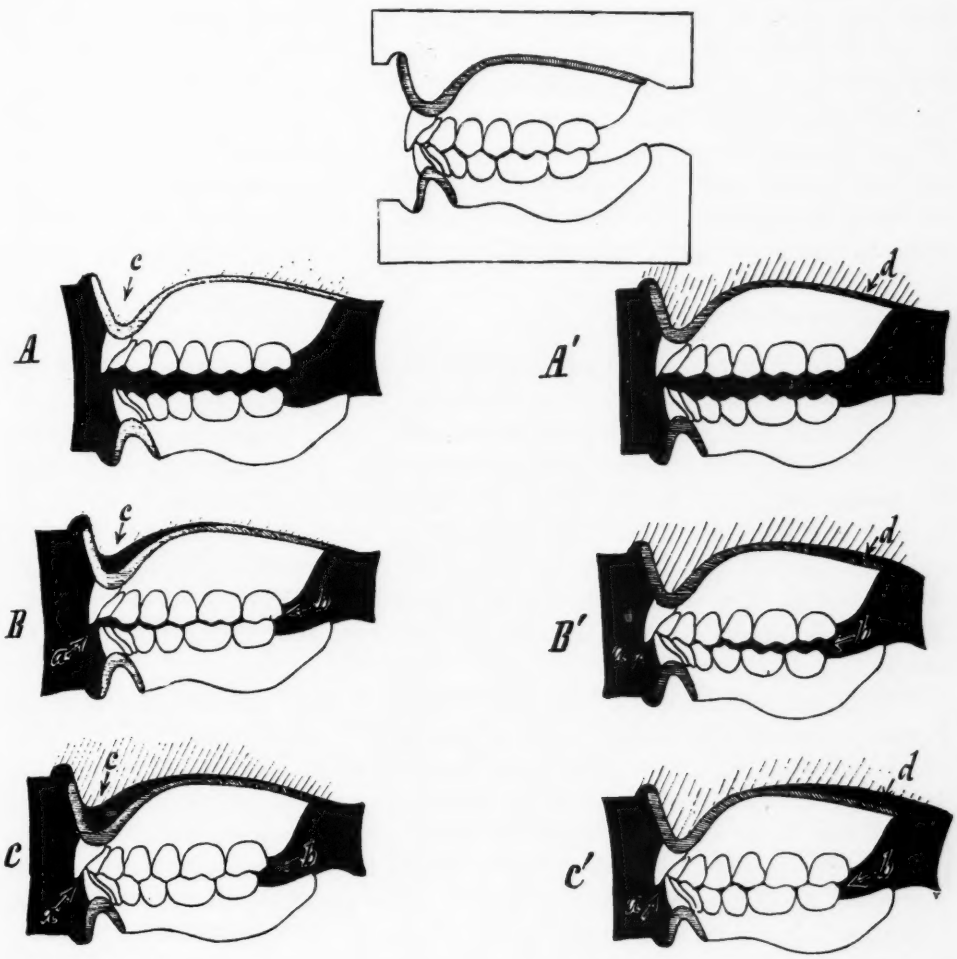

Fig. 2.—The lack of vertical equilibrium in complete dentures is shown diagrammatically. *A*, The mandible is moving in the direction of the maxillae. *B*, The contact is effected in the molar region, but there is lack of contact in the anterior region. *C*, The upper and lower dentures seemingly occlude, but the upper denture has been displaced by leverage resulting from premature contact posteriorly and is not in contact with the mucosa anteriorly. *A'*, The mandible is moving in the direction of the maxillae. *B'*, The contact is effected in the anterior region, but there is lack of contact in the posterior region. *C'*, The dentures seemingly occlude, but the upper denture has been displaced by leverage resulting from premature contact anteriorly and is not in contact with the mucosa posteriorly. (From Landa, J. S.: Practical Full Denture Prosthesis, Brooklyn, N.Y., 1954, Dental Items of Interest Publishing Co., Inc.)

have a fair knowledge of the individual problems and their sources and an elementary knowledge of physiology and psychology. To adapt to a new set of dentures, the tongue and the adjacent oral structures must develop a multiplicity of reflex actions. How soon these reflex actions may be developed, perfected, and readapted to the new environmental situations depends upon the quality of the dentures, upon the general health, age, temperament, and emotional state of the patient, and upon summation.

Summation is one of the characteristic features of reflex action in physiology. Best and Taylor[1] discuss summation and state, "Each impulse produces a state of some sort of the synapse, which is capable of being added to, or summed with, that produced by other impulses. The nature of this state produced at the synapse—the *central excitatory state,* as it has been called—is not clearly understood, but evidently it must be raised to a certain threshold value before excitation of the effector neuron can occur." To assure development of the reflexes that are necessary for the successful use of new dentures, the patient must be prepared psychologically and conditioned thoroughly to be receptive to the difficulties that he may face.

TRAUMATIC OCCLUSION

Ninety per cent of the trouble resulting from dentures is caused by traumatic occlusion, which may be considered as consisting of two kinds.

Traumatic occlusion in a vertical direction occurs when the patient closes the mouth and some of the occlusal surfaces of the artificial teeth come into contact prematurely (Figs. 1 and 2). The deflective occlusal contact may be limited to one tooth, to one cusp of one tooth, or to many teeth—the entire right side, the entire left side, all of the anterior teeth, or, as it most frequently happens, the last molars on both sides. The severity of the injury and the intensity of the pain depend upon the nature of the trauma, the teeth involved, and the susceptibility of the patient.

Traumatic occlusion in a horizontal direction implies that the trauma to the supporting structures is caused by the interferences which the mandibular teeth encounter when gliding in contact over the maxillary teeth. This usually occurs when the centric occlusion of the teeth is not associated with the centric relation of the jaws. When the patient closes in centric relation, he encounters cusp interferences that force him to glide the dentures into abnormal relations and cause trauma to the supporting structures. Also, when high-cusp teeth are used and no consideration is given to balanced occlusion, cusp interference in lateral and protrusive movements is almost the rule. A pronounced deflective occlusal contact on the balancing side is extremely damaging to the underlying mucosa. A deep vertical overlap, an excessively pronounced compensating curve, and an incorrect plane of orientation all contribute to horizontal trauma.

Whether the patient is suffering from vertical or horizontal trauma or a combination of both, he is in need of relief. The more alert the dentist is in supplying the patient with the needed relief, the greater are the chances for success. The treatment must be intelligently conceived, etiologically explored, and cautiously performed.

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REPAIR OF BROKEN LINGUAL OR PALATAL BARS

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The filled resins (the resin cements) may be used to attach pieces of metal together in the mouth or on a cast. After the resin is set, the parts can be removed from or held in their correct positions. The alignment of the parts will be more nearly correct than if an impression is made in the mouth.

When a broken lingual or palatal bar is to be repaired, make certain the broken pieces are in their correct relationship and alignment. Maintain a dry field and paint the resin cement on the break in an amount about the size of a small pea. It will not be necessary to keep the area dry during the 5 minutes it takes for the resin to set. If a number of units on a stone cast are to be attached together, they may be tried on and off of the cast a number of times, if necessary.

In some cases, the soldering may be done with the broken denture in powdered asbestos; in others, a "set" investment may be necessary. The only precaution is to remove the resin itself with an explorer point when it is warm enough to lift off of the metal easily.

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REHABILITATION AFTER PARTIAL GLOSSECTOMY

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FOLLOWING HEMIGLOSSECTOMY and radical neck dissection (Fig. 1) for malignancy of the tongue and associated structures (Fig. 1, *A*), the patient experiences residual speech impairment, disturbed deglutition and mastication, and social and psychologic handicaps. To close the surgical defect in the floor of the mouth, the surgeon must suture the remaining portion of the tongue to the mucosa at the crest of the alveolar ridge or, even more laterally, to the external oblique line (Figs. 1, *B*, and 2, *A*). Through a cooperative effort, the surgeon and the prosthodontist can correct the deformity and permit the construction and utilization of a complete lower denture (Figs. 1 and 4, *C* and *D*). The two patients in this discussion underwent hemiglossectomy with radical neck dissection *en bloc* for carcinoma of the tongue.

PRIMARY SURGERY

Primary surgery is performed to eradicate the disease; secondary concern is accorded to the functional and esthetic sequelae. After the extirpation of the tumor and healing of the wound, the patient is followed postoperatively for symptoms of recurrence. Although free of disease, the patient manifests difficulty in speech because of the immobility of the remaining portion of the tongue, incontinence of saliva, and unsatisfactory deglutition because of ineffectual tongue movement in the management of food (Fig. 2, *A*). The patient is limited to a soft diet because it is impossible to construct or wear a complete lower denture that rests upon the immobilized tongue. Because of the plastic procedure, both patients who were treated in this manner are able to wear complete lower dentures and to enjoy a regular diet, satisfactory esthetics, and distinct speech. Both patients have been rehabilitated psychologically, socially, and economically.

PRESURGICAL PROCEDURE

Special Impression Tray.—A stock metal lower tray is selected to fit the mandibular dental arch. A double-thickness shellac baseplate is adapted into this

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tray to form a basic replica of the metal tray. The baseplate tray may be altered as required.

The lingual flange of the shellac baseplate tray is warmed on the affected side and, when workable, is turned medially into the horizontal plane to cover the dorsum of the immobilized tongue. The mucosa of the tongue is continuous with the mucosa covering the crest of the ridge. Since the retromolar pad on the affected side (or if absent, the pterygomandibular raphe) is an essential landmark for adjusting the cast, the tray must be long enough to register these structures in the

Fig. 1.—*A*, A cancerous lesion is present on the lateral border of the tongue (denoted in black). The dotted line indicates the portion of the tongue, floor of the mouth, and mandible (with periosteum) to be removed. The insert indicates the position of the frontal sections. *B*, The tongue is sutured to the tissue covering the alveolar ridge after the operation. The dotted line indicates the incision for release of the tongue to create a new sulcus with a skin graft. *C*, The tongue has been released and the skin graft is in place. The graft is held by the stent which is secured to the mandible with screws through the buccal flanges. The tongue is temporarily immobilized by being sutured to the stent. *D*, The denture is in place and it permits unrestricted tongue movements.

impression. The presence of one or both of these landmarks on the cast is a crucial factor in designing the stent upon which the success of the operation depends (Fig. 2, *B*).

The baseplate tray is fitted into the mouth and any necessary adjustments are made. Strips of baseplate wax are added to the borders of the tray to create undercuts which will retain the alginate (irreversible hydrocolloid) impression material in the tray.

Oral Examination.—The lingual surface of the body of the mandible is located on both sides with the fingers, and its relation to visible landmarks, such as the retromolar pad, pterygomandibular raphe, and ridge-crest, is noted.

The proper depth of the lingual sulcus is marked on the displaced mucosa of the tongue with a soft (No. 2) indelible pencil. This line will be transferred to the alginate impression, reinforced by retracing with the pencil, and transferred to the cast.

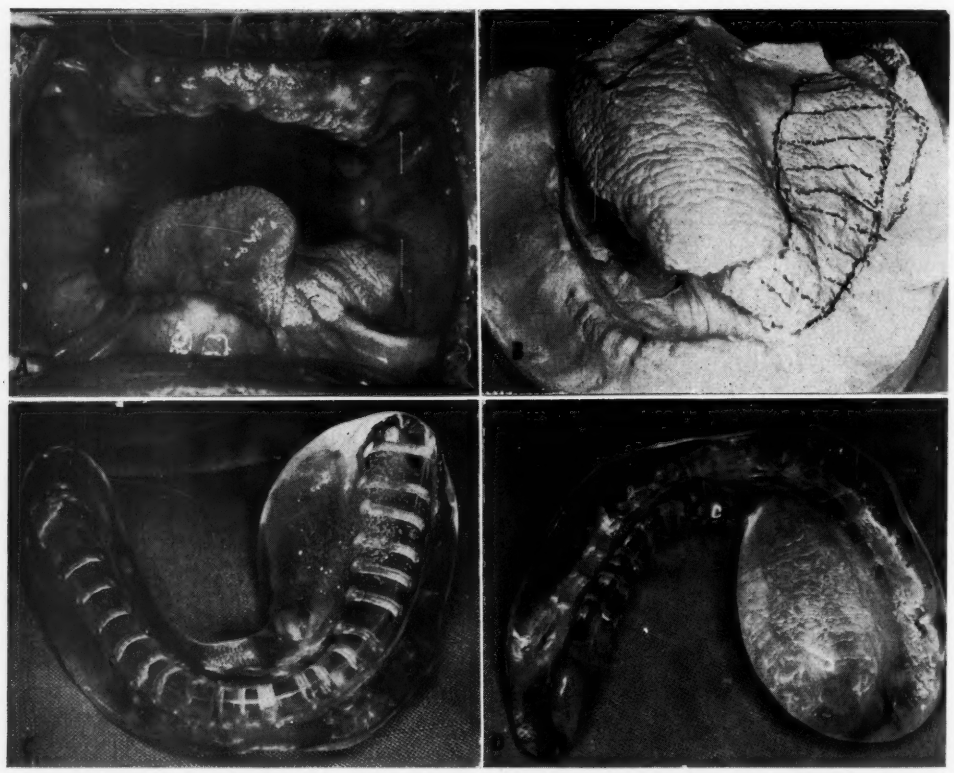

Fig. 2.—*A*, The residual part of the tongue is attached to the tissue covering the alveolar ridge following primary surgery. *B*, The proposed sulcus is outlined in pencil on the cast. *C*, The stent is made of clear acrylic resin. Note the overcorrection in the form of the broad lingual flange. *D*, The tissue surface of the stent.

Making the Impression.—An alginate impression material is used to make the impression. An excess of the material is placed upon the dorsum of the tongue so that it will be well delineated. The impression is poured in plaster of Paris to form a cast.

Modifying the Cast.—An alveololingual sulcus is created on the side which was operated upon by carving the plaster cast. The line indicated by the indelible pencil, observation of landmarks, and palpation on both sides of the mouth are used as guides. The sulcus is cut deeper and wider than that on the normal side

of the cast to allow for some shrinkage of the graft when the stent is removed. Allowance is made for retention of an appreciable thickness of soft tissue upon the lingual aspect of the body of the mandible (Figs. 1, *B* and 2, *B*).

Fabrication of the Stent.—The stent is waxed similarly to a denture base, but the lingual flange on the side operated upon is waxed to a greater thickness with blunt, broad borders (Fig. 2, *C* and *D*). A "dorsal fin" of two thicknesses of baseplate wax is applied to the crest of the ridge from the midline to the second molar on the affected side. After curing, holes are drilled in this upright ridge, and during the operation, the tongue may be sutured to it for temporary immobilization. The buccal flanges of the wax pattern are extended for proper placement of Vitallium screws. Holes are drilled in the stent to admit the screws.

The wax pattern is flasked and cured in clear acrylic resin. The stent is cured at 160° F. for 8 hours and then boiled for 2 hours. The prolonged curing prevents porosity and minimizes the amount of residual free monomer which would be an irritant to the skin graft. All sharp borders of the stent are trimmed and polished for increased tissue tolerance.

Sterilization.—The stent is washed with soap and water, rinsed well, and immersed for 30 minutes in 10 per cent formalin solution.[1] The stent is rinsed again and stored in 1 :1,000 Zephiran until used.

SURGICAL TECHNIQUE

The operation is performed under general anesthesia with nasotracheal intubation. Hairless areas on the medial aspect of the thighs are used for the donor sites. The donor sites are prepared separately. The split-skin grafts are cut with a Brown dermatome set at 16/1,000 of an inch. After the graft is cut, it is placed back in its original location and a moist saline sponge is placed over it.

Then, an incision is planned in the mouth to release the remaining portion of the tongue from its attachment to the body of the mandible and buccal mucosa. The incision is made parallel to the mandible through the scar tissue, leaving the residual fibrous scar on the inner surface of the mandible, which had been previously stripped of its periosteum during the original operation (Fig. 1, *B*). The incision is deepened to just above the inferior border of the mandible, the excessive scar tissue is excised, and the remaining portion of the tongue is mobilized completely. The mucosa of the tongue is undermined dorsally and advanced laterally to form a new lateral border for the remaining part of the tongue (Fig. 3, *A*). The tip of the tongue is modified to create a broader anterior margin.

The previously prepared acrylic resin stent is tried in by the prosthodontist, and the newly created sulcus is adjusted to allow the stent to seat properly (Fig. 3, *B*). The clear resin permits direct visual observation of blanched tissue on either side of the mouth. Failure to eliminate tissue displacement would be followed by pain and necrosis of the mucosa.

The previously prepared skin graft is detached from the thigh and placed, with its raw surface exposed, on the tissue surface of the stent (Fig. 3, *C*). Supported by the stent, the skin graft is carried into the mouth with the stent and positioned properly in the newly created alveololingual sulcus. The edges of the graft on

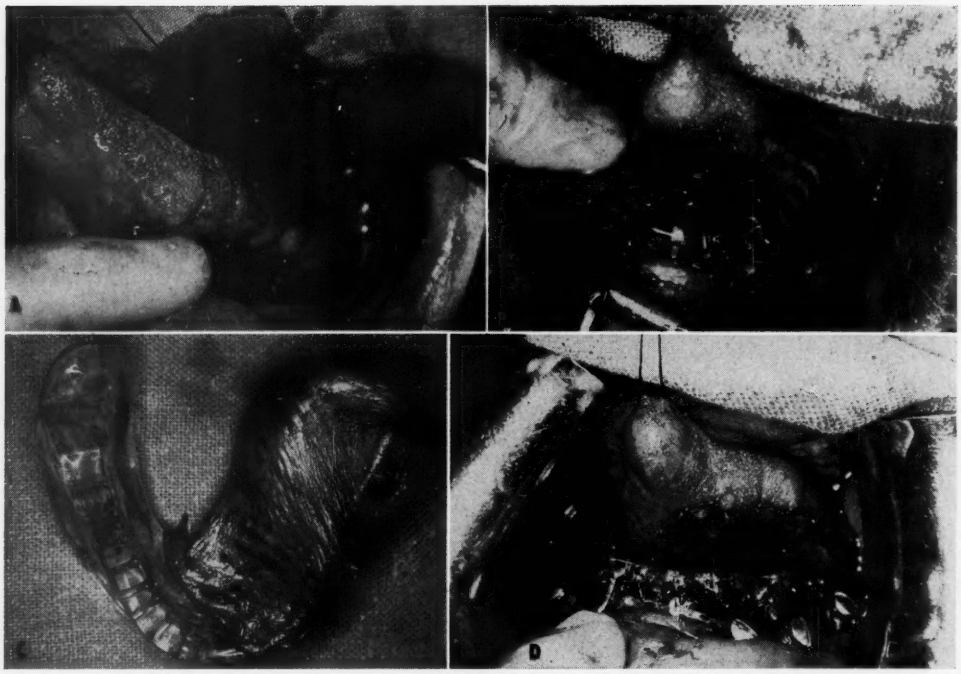

Fig. 3.—*A*, The residual part of the tongue is released and the lateral border is recreated on it. The tongue can make free movements. B, The stent is tried in the mouth and the blanching of tissue is observed through the clear acrylic resin to determine the need for modification of the sulcus. *C*, A split-thickness skin graft from the thigh is placed on the stent with the cut surface exposed. *D*, The skin graft is sutured to the newly created lateral border of the tongue, and the stent is attached to the mandible with Vitallium screws.

the lingual side are sutured to the undersurface of the newly created lateral border of the tongue (Fig. 3, *D*). The buccal margin of the graft is not sutured. The tongue is immobilized by attaching it to the stent with deep sutures (No. 2-0 black silk) which are led through previously made holes on the ridge portion of the stent (Figs. 4, *A* and 1, *C*). Single strips of sterile muslin gauze are placed on the donor sites.

Postoperatively, the patient is fed through nasogastric tubes, and the oral cavity is irrigated with warm saline solution every 2 hours. The stent is left in place for 10 days.

Finally, new dentures are constructed. It is undesirable to allow these patients to go without dentures for any length of time, because continuous occupation of the new sulcus by an appliance is necessary to prevent excessive shrinkage of the graft. A minimal pressure technique is used in the impression procedure, and the maxillomandibular relations are secured by using a central bearing device and Gothic arch tracing (Coble balancer). Monoplane posterior teeth are used and ground into a reverse occlusal curve with balanced occlusal contacts.[2,3] This achieves the maximum stability of the lower denture during mastication (Figs. 1, *D* and 4, *D*).

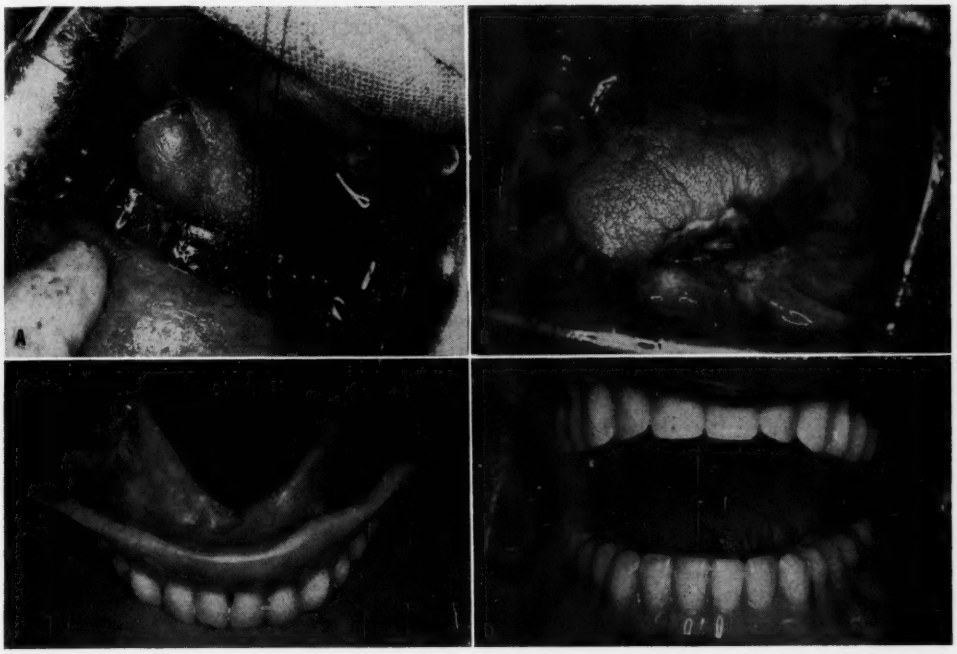

Fig. 4.—*A*, The tongue is released and then sutured to the stent for its temporary postoperative immobilization. *B*, The tongue is released; a new lingual sulcus has been created. The color of the graft is characteristic of Negroid tissue. *C*, The completed lower denture maintains the newly formed alveololingual sulcus. *D*, The new dentures are in place in the mouth.

DISCUSSION

The technique described is used when there is a complete loss of the musculature comprising the floor of the mouth on one side, where it has been replaced by dense fibrous connective tissue (Fig. 1, *B*). Figi and Masson[4] reported the use of a skin graft following irradiation and electrocoagulation for a squamous cell carcinoma of the floor of the mouth. They refer to Esser[5] as the first to report the use of skin grafts in the mouth, a measure later popularized by Gillies[6] in the closure of war wounds during World War I.

In relation to denture prosthesis, skin grafting in the oral cavity has been used mainly in the creation of buccal and lingual sulci to overcome severe resorption of the alveolar ridge.[7-9] The underlying base for these grafts has been the normal musculature of the floor of the mouth. The soft, displaceable tissues in this part of the mouth contribute little to the *stability* of a lower complete denture, but aid considerably in its *retention*.[10] When this soft tissue is replaced by tough scar tissue, as usually occurs after a skin graft, the scar tissue cannot provide the type of seal against the lingual flange that is required for good retention. However, the patients being considered presented not merely the problems of low ridges and shallow sulci (and hence short denture flanges); in addition, the mucosa of the residual part of the tongue had been sutured to the crest of the ridge in the process

of closure after the primary operation. Thus, construction of any lower denture was impossible without some corrective surgical measures.

The construction of a properly contoured and accurately fitted stent provides a simple and efficient means of positioning and retaining the skin graft during and after surgery. Without the stent as a carrier, the proper placement of the delicate skin graft is an awkward and laborious procedure. The stent guides the surgeon in locating the graft in the lingual sulcus and holds the graft smoothly in place for suturing (Fig. 3, *C*). Postoperatively, the stent maintains the sulcus and prevents excessive contracture. The stent serves also to inhibit undesired tongue movement during the immediate postoperative period (Figs. 4, *A* and 1, *C*). Finally, the stent is used for maxillomandibular registrations and as a base for the construction of a provisional lower denture (in 1 day) to be worn until a more perfect denture can be fabricated.

The results with the first patient were not entirely satisfactory, but this experience contributed to improved technique for the second one. There was scarring and shrinkage of the new lingual sulcus. Release of the tongue, however, improved speech and mastication after a denture was made. A review of the technique revealed defects in the design of the stent. The lingual flange of the first stent was not deep or broad enough to establish the overcorrected sulcus which compensates for subsequent tissue shrinkage. Barsky and McIndoe[11, 12] have emphasized this point and also recommend that the stent or denture be worn for several months postoperatively. The sulcus established for the second patient was deeper and wider, to compensate for anticipated tissue contraction (Figs. 1, *C* and 2, *B* and *C*).

Another adverse factor with the first patient was the circumferential wiring used to stabilize the stent. It was difficult to place the wire through the skin graft without displacing or tearing the graft. Vitallium screws through holes in the buccal flanges of the stent were used for the second patient. These screws were easier to insert and more effective than the circumferential wires (Fig. 3, *D*). The screws were removed easily after 10 days.

SUMMARY

A technique for the reconstruction of the floor of the mouth and tongue following hemiglossectomy and radical neck dissection has been presented. Plastic surgery was performed to permit fabrication of dentures and to restore masticatory and speech function by increasing the mobility of the tongue. The methods employed are variations of techniques used in the past.

Cooperation between the surgeon and prosthodontist is fundamental to the success of the procedure and in the rehabilitation of this type of patient.

We gratefully acknowledge editorial and other assistance by Dr. M. A. Pleasure and guidance by Dr. B. M. Hoffman, based upon his abundant experience in surgical prosthodontics.

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CLINICAL OBSERVATIONS ON A NEW DENTURE ADHESIVE

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A DENTURE ADHESIVE may be required under various circumstances of dental practice. Such circumstances may be the difficult and demanding patient, poor ridge anatomy and relationships, a complete denture opposed by natural teeth, or the necessity of optimal denture retention.

An evaluation was made of a new denture adhesive.§ The paste adhesive studied is composed of gelatin, pectin, carboxymethylcellulose, and Plastibase (a mineral oil-polyethylene vehicle). Each of these ingredients apparently is essential, especially the gelatin. A powder adhesive was studied also. It is composed of the three powder ingredients, with the Plastibase vehicle omitted.

The ingredients in this adhesive are well known and their properties have been described adequately.[1-4] All of the ingredients are nontoxic and noninjurious systemically when used in the proportions and amounts needed for a denture adhesive.

The characteristics of these denture adhesives result from the unique physical properties of gelatin, pectin, and carboxymethylcellulose. The mineral oil-polyethylene base (Plastibase) is a relatively nonallergenic, viscous, but easily spread vehicle into which comparatively large amounts of active powder ingredients can be incorporated. The results of a comparative evaluation of various formulations of this material against gum karaya, the ingredient present in many commonly used denture adhesive powders, are also presented.

METHODS

Sixty edentulous patients, aged 38 to 83, 21 men and 39 women, were studied. New dentures had been constructed in the prosthetic clinic for 56 of these patients during the previous 6-month period, and 4 patients were wearing older dentures.

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*With the assistance of Drs. Richard Castoria, Philip Fenster, Russel Garofolo, David Hendell, Theodore Rosov, and Alex Dell.

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§The experimental denture adhesive preparations for this study are available from E. R. Squibb & Sons as "Orahesive" paste and "Orahesive" powder and were provided by The Squibb Institute for Medical Research, New Brunswick, N. J.

An examination was made of the oral cavity, and notation made of soft tissue disease, adaptation of the denture base to the tissue, denture retention, and stability. Thereafter, three adhesives (labeled in code as P, R, or O) were provided to each patient. The patient was requested to use the adhesives in the order appearing on a card (on alternate days) as often as they chose and to report their observations on the degree and duration of retention and comfort resulting from each of the various denture adhesives. The patients used each for at least 2 full days and in some instances all three adhesives were used for 3 days each.

The three formulations studied were: P, a fine-grind powder mixture of gelatin, pectin, and carboxymethylcellulose; R, an equivalently fine-grind powder of pure gum karaya; and O, the identical ingredients of powder P mixed in the polyethylene-mineral oil base. A sufficient quantity of the powders was incorporated in mixture O to produce a thick but easily spread paste.

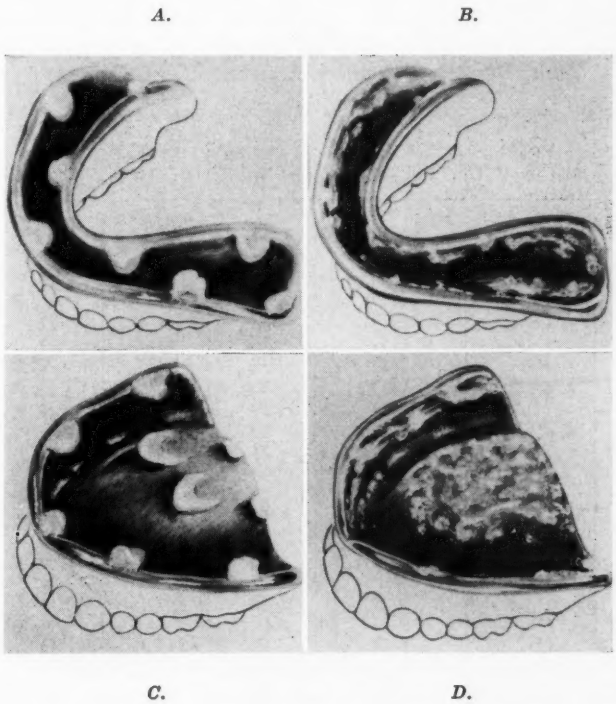

Fig. 1.—Stages in the technique of application of the experimental denture paste. *A* and *C*, The initial deposits of adhesive paste are on the denture. *B* and *D*, The adhesive is distributed before the denture is inserted in the mouth.

The technique of applying the adhesive paste was as follows: It was applied to the *dry* dentures (Fig. 1). A small amount (about ¼ inch) was squeezed directly from the tube onto the inner surface of the border of the denture at 1 inch intervals along the entire border. In addition, small amounts of paste were applied at two places in the center of the upper denture. Then the material was spread over the entire *inside* of the border of the dentures with the finger. The material in the

middle of the palate was spread thinly over the inner surface. The dentures were inserted into the mouth immediately and pressed firmly against the tissue with closing pressure. The adhesive was allowed several minutes to "gel" before eating or drinking. The application was repeated as required.

The technique of applying the denture adhesive powders was similar to that utilized for other available denture adhesive powders. The denture powder was applied liberally to the wet denture. The denture was turned over so that the excess powder dropped off. Then the dentures were inserted in the mouth and pressed firmly against the tissue with closing pressure. The adhesive was allowed several minutes to "gel" before eating or drinking. The application was repeated as required.

All patients were thoroughly instructed both verbally and by demonstration in the use of the various materials. In addition, a written instruction sheet summarizing the technique of application was given each patient.

TABLE I. COMMENTS OF 60 COMPLETE DENTURE PATIENTS ON TWO EXPERIMENTAL DENTURE ADHESIVES AND A CONTROL ADHESIVE (GUM KARAYA)

PATIENT NUMBER	LONGEST ACTION	MOST RETENTION	UNDESIRABLE PROPERTIES	PATIENT NUMBER	LONGEST ACTION	MOST RETENTION	UNDESIRABLE PROPERTIES
1	O	O	ND	31	R	R	O
2	R	R	O	32	R	R	O
3	R	R	O, P	33	P, O	P	O
4	R	R	ND	34	O	R, P	O
5	O	O	ND	35	R	R	O
6	O	O	ND	36	O	O	ND
7	R	R	ND	37	ND	ND	ND
8	O	O	ND	38	O, P	O, P	R
9	ND	ND	ND	39	R	R	O
10	O	P	R	40	O	O	O
11	R	R	O	41	ND	ND	ND
12	O	O	P	42	O	P, O	O
13	O	O	ND	43	O	O	ND
14	O	O	O	44	O	R, O	O
15	P	P	ND	45	P	P	ND
16	O	O	ND	46	O	O	ND
17	R	P, O	R	47	P	P	O
18	P	P	ND	48	O	O	O
19	O	O	ND	49	P	P	O, P, R-ND
20	ND	O	ND	50	O	O	ND
21	O	O	R, P	51	P	P	O, P, R-ND
22	O	O	P	52	O	O	ND
23	P	P, O	ND	53	O	O	O
24	O	O	P, R	54	P	P	ND
25	ND	P	ND	55	P	P	O
26	O	O	O	56	O	O	ND
27	R	R	ND	57	O	O	ND
28	R	R	O	58	O	O	O
29	P	O	ND	59	P	P	ND
30	R	R	ND	60	O	O	ND

P = A fine-grind powder mixture of gelatin, pectin, and carboxymethylcellulose.
R = An equivalently fine-grind powder containing only pure gum karaya.
O = The identical ingredients of powder P in a polyethylene-mineral oil vehicle (Plastibase), the powders incorporated therein in quantity sufficient to produce a thick but easily spread paste.
ND = No difference noted among any of the three adhesives tested.

TABLE II. SUMMARY OF COMMENTS OF 60 COMPLETE DENTURE PATIENTS ON TWO EXPERIMENTAL DENTURE ADHESIVES AND A CONTROL ADHESIVE (GUM KARAYA)

QUALITY	DENTURE ADHESIVE			NO DIFFERENCE NOTED
	P	R	O	
Longest duration of action	12	13	30	5
Most retention	14½	13	29½	3
Undesirable properties	7	7	22	33
In most instances comments of patients as to undesirable properties of the adhesives tested were confined to the broad generalization of "unpleasant." Occasionally patients reported more specific and more emphatic complaints, which are listed below:				
1. Texture unpleasant			(1)	
2. Difficulty in removing adhesive from tissues			(1)	
3. Slimy		(1)		
4. Gagging or nausea	(1)	(2)	(1)	
5. Taste unpleasant	(1)	(2)	(8)	
6. Lumpy		(1)		
7. Caking	(1)	(1)		
8. Foaming	(1)			
9. Messy			(2)	
10. Dry			(1)	
11. Too tight			(2)	
12. Difficult to apply			(1)	

The order of use of the three adhesives for each patient was randomized by drawing lots. All patients received all three adhesives and thus served as their own controls.

Upon return to the clinic the patient was asked three questions identically phrased to all patients. The questions were: (1) Which adhesive caused the dentures to remain firmly in the mouth for the *longest* time? (2) Which adhesive caused the dentures to be the *most firm* or tightest (to give the most retention) during eating, drinking, and talking? (3) Were you aware of any unpleasant characteristics of any of the three adhesives? If yes, with which adhesive? What were the unpleasant characteristics noted? When a patient reported two preparations were equally useful (in terms of their "first choice"), a recording of one-half was made for each of the two preparations on the first two questions.

RESULTS

The results in terms of the reports of the patients appear in detail in Table I and are summarized in Table II. The following findings seem pertinent:

1. More patients (30) preferred the experimental paste adhesive than either the control gum karaya (13) or the experimental adhesive powder (12) in terms of *duration* of firm retention. Five patients found no difference among the adhesives tested.

2. More patients (29½) preferred the experimental adhesive paste than either the control gum karaya (13) or the experimental adhesive powder (14½) in terms of *degree* of retention during normal activity and function. Three patients found no difference between the adhesives tested.

3. More patients (22) found the experimental adhesive paste unpleasant than either the control gum karaya (7) or the experimental adhesive powder (7). Thirty-three patients found no difference among the adhesives tested. The character of these complaints and the frequency are included also in Table II. Some patients found more than one of the adhesives to be unpleasant.

Particular attention was paid to the observation (by inspection) of any evidences of toxicity, side reactions, irritation, or inflammation, and also to subjective comments indicative of allergy, etc. No such reactions were observed in any patient.

DISCUSSION

Most of the patients could be divided into two pairs of groups: (1) preference for the experimental adhesive paste or experimental powder over the gum karaya, or vice versa, and (2) preference for the adhesive paste over either powder, or vice versa.

The significance of these groupings is as follows: The two experimental adhesives (essentially similar in action but different from karaya) appealed to some patients as a pair. The same adhesives failed to please some patients also as a pair, often for reasons of "unpleasantness" attributed to both these materials but somewhat more often to the paste. There was frequently difficulty in choosing between the experimental paste and powder when this *pair* was preferred, although the final choice was usually the paste. Thus, had only the experimental powder and gum karaya been compared, it seems probable that a similar proportion of those who stated a preference for the paste would have voiced a preference instead for the experimental powder since the two experimental adhesives share common activity and retentive properties.

The relative advantages and disadvantages of a powder versus a paste formulation are often felt to be of importance by the patient. It seems probable, however, that no paste formulation will be found so superior as to result in all patients choosing it rather than a powder or vice versa. It is interesting that many patients who "objected" to the paste formulation nevertheless preferred to continue its use. Two patients who described the paste as superior in terms of retention and duration of action preferred to use the powder preparations because of objectionable properties of the paste (one complaining the denture was held too tightly).

Denture adhesives should *not* be used wherever well-fitting dentures are tolerated by the patient. From the standpoint of hygiene, it is more difficult to maintain a scrupulously clean denture when adhesives are used. Also, a patient should not be permitted to use a denture adhesive when its application seemingly (to the patient) restores an ill-fitting and irritating denture to such a degree of function and comfort as to allow or encourage the continued use of these dentures. This is particularly important since patients are usually not aware of the damage that ill-fitting dentures can produce to the underlying soft tissue whether used with or without an adhesive.

SUMMARY

Clinical tests on 60 subjects were made comparing gum karaya (one of the more commonly used denture adhesives) with two experimental formulations of materials intended for use as a denture adhesive. The results of these tests indicate definite preferences of certain subjects among the denture adhesives studied. No adverse reaction of an allergic, toxic, or traumatic nature was noted following the use of any of the denture adhesives studied.

The authors are indebted to Mrs. Florence V. Moore, Mrs. Doris Tormes, Miss Joan Graham, and Mrs. Edna McNeill for their assistance in coordinating these studies and to Mrs. Eileen Geller and Mrs. Helene W. Kutscher for their services.

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ESTHETICS AND HYGIENE AFTER EXTENSIVE PERIODONTAL TREATMENT

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MANY PATIENTS have been left with unsightly oral structures following the removal of gum tissue and alveolar bone to cure periodontal disease. With the eradication of the pathologic pockets, the bone and gingival tissues receded leaving the roots of the teeth exposed and the interproximal embrasures enlarged (Fig. 1). These embrasures are not only unsightly, but they act as food traps creating an additional problem of maintaining adequate hygiene in the mouth of a patient already burdened by difficult and time-consuming home care. The dental prosthesis to be described is offered to obtain better appearance and maintain better mouth hygiene.

ARTIFICIAL RESIN MASKS

People wear artificial nails, eyebrows, eyelashes, wigs, eyes, and many other forms of removable prosthesis to hide abnormal or unsightly conditions. Artificial resin masks hide unsightly oral tissues and cover exposed roots. These gum sections need be worn only when desired. They can be inserted and removed with little effort, provide a pleasing appearance, and close the large interproximal embrasures. They shorten the apparently oversized teeth, cover the exposed roots, prevent the accumulation of food between the teeth, and are inexpensive to make. Above all, they give the patient a tremendous mental and moral lift.

TECHNIQUE OF CONSTRUCTION

Acrylic resin gum masks are made in the following manner. An accurate alginate impression is made of the upper teeth including the labial and buccal gingival tissue, and a stone cast is poured. Modeling compound is adapted to the palate of the cast to form a core (Fig. 2). The palatal modeling compound has extensions which just enter the interproximal embrasures from the lingual side of the teeth. This core is used to prevent the impression material from running into the embrasures from the labial and buccal tissues when the final impressions are made. A cold-cure acrylic resin tray is made for the labial and buccal surfaces. This tray will carry the final impression material so that a detailed impression can be obtained of the teeth, interproximal embrasures, and gingival tissue.

The palatal core is placed into position and the final impression is made with rubber-base or silicone impression material in the special tray (Fig. 3). A correct impression records all the detail of the labial and buccal gingivae and frenum as well

A. *B.* *C.*

Fig. 1.—The right *(A)*, anterior *(B)*, and left *(C)* views of a young female patient after periodontal surgery. The roots are exposed and unsightly. The embrasures are large and prevent good oral hygiene.

Fig. 2

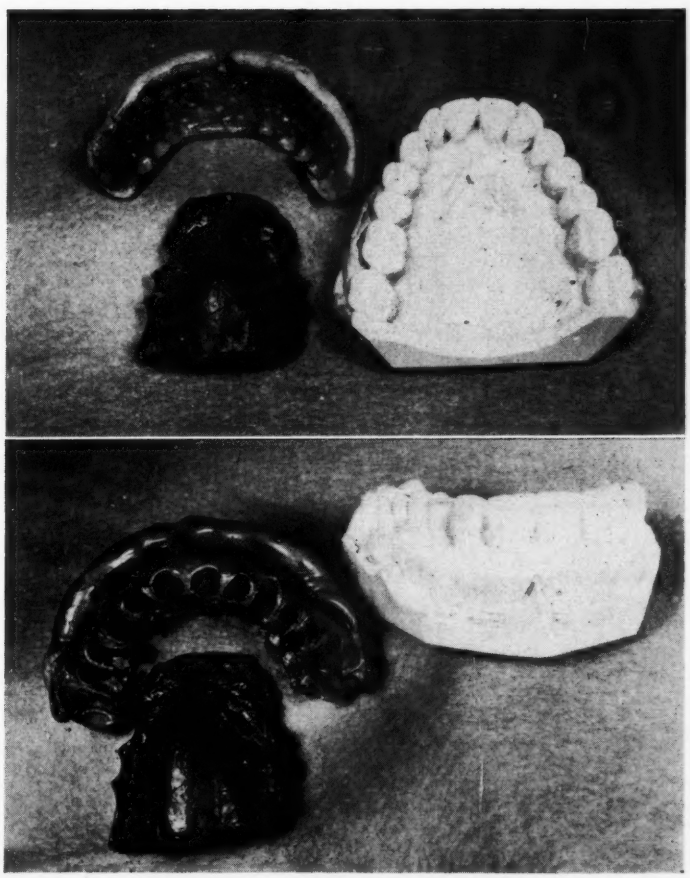

Fig. 3

Fig. 2.—The stone cast is made from an alginate impression. The modeling compound palatal core prevents impression material from running through the interproximal embrasures. The cold-cure acrylic resin buccal and labial impression tray is painted with rubber cement.

Fig. 3.—The rubber-base impression gives an accurate reproduction of the buccal and labial tissues as well as the interproximal embrasures.

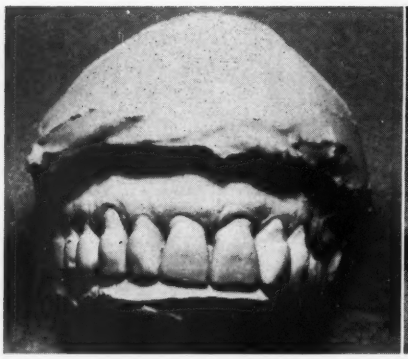

Fig. 4

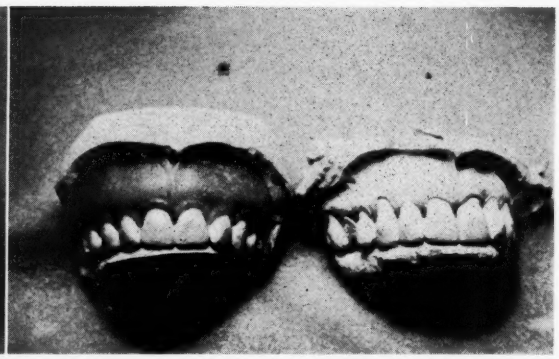

Fig. 5

Fig. 4.—The stone cast is made from the rubber-base impression. Note the detailed tooth and tissue anatomy.

Fig. 5.—The mask is waxed on the stone cast. The duplicate cast is on the right.

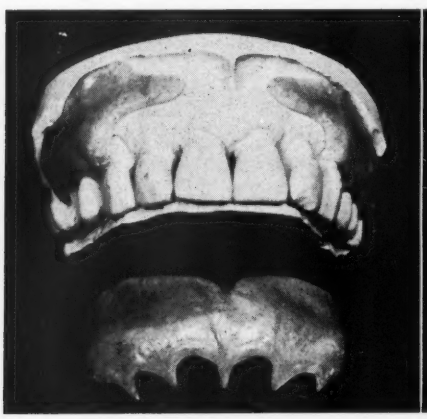

Fig. 6

Fig. 7

Fig. 6.—This resin mask is made in three sections. The anterior section fits over the extensions of the posterior sections. The interproximal projections act as retentive devices.

Fig. 7.—The disassembled parts of the mask are in the foreground. The joints are invisible in the mouth.

A. *B.* *C.*

Fig. 8.—The right *(A)*, anterior *(B)*, and left *(C)* views of the patient shown in Fig. 1, with the acrylic resin masks in position.

as the labial surfaces of the teeth, including their incisal edges. The interproximal embrasures must be especially detailed because they must be filled accurately and covered with the plastic mask (Fig. 4).

The mask is waxed and carved and processed on the cast in heat-cured acrylic resin (Fig. 5). The processed mask is refitted on a duplicate cast and is ready for insertion. The projections of the plastic mask into the embrasures hold the mask in position without the aid of any other form of retention.

If the bicuspids and molars are involved, the mask may have to be made in two or three sections to permit its insertion (Figs. 6 and 7). The mask may be made for any section of the mouth and may be colored and contoured to represent the natural gums (Fig. 8). These masks may be worn on all occasions, or only on special occasions. They are readily removed and cleaned.

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REMOVABLE PARTIAL DENTURES

THE DENTIST, THE PATIENT, AND RIDGE PRESERVATION

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OUR PHILOSOPHY regarding the patient, the preservation of ridges, the remaining teeth, and the supporting alveolar process has been influenced by several premises. Included in these are: (1) The patient's financial situation should in no way interfere with his being advised of the method of treatment which is best suited to his individual needs. (2) No matter how irritating the patient or how repulsive his mouth, each is entitled to the utmost consideration and neither should be subjected to "the space-filling concept."[1] (3) Ridge preservation must start at the time of the initial examination. (4) Ridge preservation should be kept in mind continuously, from the preparation of the mouth until after the prosthesis is completed.

Applegate,[2] Metty,[3] McCracken,[4] and Steffel† have described methods of examining soft tissue and evaluating the bone which is subjacent to the denture base and the alveolar process supporting the abutments. Metty[3] states, "The soft tissue under partial denture bases is very much an innocent victim of circumstances. It functions because it is trapped. Some functions have been assigned to this tissue by Nature, but these do not include the bearing of the partial denture base. However, if treated kindly and on its own terms, it will transmit the force applied by the base to the underlying bone, and, better than that, it will give warning if the stress or load applied tends to concentrate in a small area. All that it demands in return is nourishment and a little regular stimulation. While the underlying bone is recognized as the true foundation, it is necessary to concentrate on the soft tissue into which we direct the forces coming upon the partial denture for transmission to the bone, and which we carefully watch for an indication of how the bone is reacting."

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†Dr. Victor L. Steffel, Postgraduate Course, The Ohio State University, 1947.

PRELIMINARY PLANNING

Study casts mounted on an adjustable articulator are essential both for making a preliminary design for a removable partial denture which will induce minimal resorption and for planning all of the treatment, including the preparation of the mouth.[4] These casts, made from accurate impressions, must be related correctly on the instrument in all measurements. If occlusion rims are necessary for a face-bow mounting, they should be constructed.

The patient must understand that treatment is already in progress and that the rebuilding of the mouth will be for the maximal period. He must be convinced of the necessity for sound treatment and of the dentist's belief in this treatment; further, the patient must realize that he has an important part in the ultimate success of the treatment. He must be persuaded to accept the situation and his own future responsibilities, whether the prognosis be favorable or unfavorable. If this acceptance is not forthcoming, there is no legal or moral obligation for proceeding.

The dentist must have an abiding faith in the type of service proposed. This need is reflected in discussions with the patient and has much to do with a reciprocating confidence. Dramatics and stage setting may be effective in some instances, but sincerity will be more persuasive than a special chair, soft music, air-conditioning, parking space, or a budget plan.

MOUTH PREPARATION

Mouth preparation can range from the preparation of occlusal rest seats in the enamel and the grinding of guiding planes on axial surfaces of the teeth to the construction of crowns and fixed partial dentures to accept retentive and stabilizing clasps and minor connectors and secondary retainers. Surgery may be indicated, or it may be necessary to reconstruct or reshape the opposing teeth. In order to recondition the mouth and ridge tissue, an "exercise" prosthesis may be desirable.[5]

Mouth preparation is done for definite reasons.[6] These are to (1) preserve the structures which remain by preventing destructive forces or processes, (2) facilitate and regulate the retention of and to increase the stability of the prosthesis, (3) design a prosthesis which can be made and kept benign in its relationship to the supporting structures, and (4) permit the addition of teeth or the changing of clasps if an abutment is lost.[7]

Abutment teeth must be recontoured so that (1) the clasp arms may be positioned close to the center of rotation of the tooth, (2) the reciprocating arm of the clasp will support the abutment during the entire period that the retentive arm is flexing and passing over the height of contour into the retentive undercut, (3) the rest seats may be positioned advantageously in relation to the lines of force which will be directed against the abutment, and (4) the rest seats can be cut deep enough that the occlusal rests will have strength to support the prosthesis without being overcontoured to the point of inducing traumatic occlusion.

The caries index of the mouth indicates which methods of mouth preparation should be used. If the caries susceptibility is high, any tooth which is to be clasped or which is to support a secondary retainer should be crowned. The crown-root

ratio of the teeth involved and retention and support of the partial denture will dictate the need for splinting. Consideration should be given, however, to the possible periodontal sequelae of mouth preparation. If the clinical crowns of the involved teeth are short, and if the soldered joints needed to tie these teeth together would obliterate the embrasure, a plan of treatment should be evolved which does not require splinting. Also, gingival tissue is not always placidly receptive to crown margins. There is entirely too much indiscriminate yielding to the full-coverage fad.

The total treatment plan must provide protection for the gingival tissue around the abutment tooth and the underlying bony crest, particularly, if the prosthesis involves a distal-extension denture base. The abutment tooth must be prepared or recontoured so that the retentive arm can move away from the tooth or flex in all directions under masticatory force. However, if the distal contour of the abutment is inadequate or if the denture base and minor connector are not curved away from the tooth sufficiently in the cervical third, malignant impingement of the subjacent tissue can occur.

IMPRESSIONS

The impression for the master cast is made when the mouth preparation has been completed. Metty states that all impression techniques, if used methodically, will produce a serviceable base. With this we agree. Applegate uses a fluid wax impression technique. In expert hands, the fluid wax impression will assist in forming a base which is adapted not only to the supporting structures, but which usually is extended accurately to maximal coverage. A partial denture constructed on a corrected functional cast should require less than normal postinsertion adjustments and should effectively retard ridge resorption. However, the flow of the wax is hard to control and the procedure is time consuming and difficult.

An individual tray is essential, regardless of the impression material. If alginate (irreversible hydrocolloid) is used, the tray must be constructed to permit more bulk of impression material than is necessary with Thiokol.* Tray rigidity is mandatory. The tray must cover every structure of even the slightest importance to the stability of the base, yet must not displace soft tissue in any way. The tray must be constructed so that it can be removed from the mouth without permanent distortion or tearing of the impression material.

Reversible and irreversible hydrocolloid, Thiokol, and other impression materials are subject to internal strains and react to atmospheric conditions. If the casts are not poured immediately, distortion occurs and results in ill-fitting bases and castings. The impression for a Class I (Kennedy classification) prosthesis should extend distally to include all of the retromolar pad and should extend buccally to include, but not distort, the mucobuccal fold. The maxillary tuberosities, the vibrating line, the hamular notch, and the mucobuccal fold must be copied and reproduced in the cast. The tray must not distort the retromolar pad. There can be no discernible pressure points if the impression is to be acceptable. An accurate impression should produce an accurate cast. This is one of the fundamentals of healthy soft

*Polysulfide rubber.

tissue and preserved ridges. Tooth form and occlusal rest preparations must be copied without distortion or bubbles.

FRAMEWORK DESIGN

Major and minor connectors and clasps, as well as the extensions for the retention of the base, must be contoured to clear tissue and to eliminate torque on the abutments. The major connectors must be rigid. In function, they must be abetted in controlling undue lateral pressure by reciprocal clasp arms which are tapered for a cushioning flexibility and located above the survey line of the abutment teeth. Lateral movement is controlled by more rigid reciprocal clasp arms in Class III and Class IV prostheses. The rigidity of the major connector is important in controlling unwanted lateral pressure on the ridges in Class I and II partial dentures.

Provided rigidity is established, it is of little significance whether the framework is made of gold or chrome-cobalt alloy. Nondestructive clasping can be accomplished with either.[8] Mouth preparation acceptable for one metal, however, is not suitable for the other. Heights of contour must be reduced for the chrome-cobalt alloys so that retentive undercuts will be shallow. Embrasures to accept struts may be nearly normal in contour when chrome-cobalt alloys are used. If mouth preparation is designed in accordance with the metal used, there seems to be little difference in the end result so far as abrasion of enamel, burnishing of crown surfaces, or ridge resorption is concerned.

JAW RELATIONS

The casting is tried in the mouth, and the occlusion of the rests is adjusted. Then, the occlusion rims are constructed on the metal frameworks. Kerr's Correcto wax, No. 1, is used as the base for the registration. It may be molded to fit the master cast and will not distort at mouth temperature. The occlusion rim is built high enough to barely contact the opposing teeth and is undercut to hold zinc oxide and eugenol impression paste. The ensuing maxillomandibular registration must be precisely made.

Most removable partial dentures should be constructed to utilize the existing centric occlusion and vertical dimension, even though they may be an eccentric position and a reduced vertical dimension. Patients free of symptoms should be left free of symptoms. All too often, changes effected through partial dentures induce stumbling blocks for the patient. Among these is ridge resorption.

DENTURE BASE CONSIDERATIONS

The denture base for a Class I lower removable partial denture must be extended to provide maximal tissue coverage and must be extended distally to include all of the retromolar pad, unless a muscle attachment is involved. The same rule must be observed for a Class II design. If there is a modification space which cannot be restored by a fixed prosthesis, minimal ridge coverage is indicated because the modification section will be supported on both ends by competent occlusal rests.

Class III prostheses are usually supported by abutment teeth at four points. When an edentulous span terminates at the distal surface of a lateral or central incisor, the lingual surface of the abutment must be prepared so that the load transferred from the rest will be directed in line with the long axis of the abutment. This protects the ridge tissues, especially the alveolar process next to the abutment. Applegate and Metty advocate the use of the corrected functional impression in such a situation and believe that support on the abutment tooth may not be necessary. However, we support the denture with a rest on a prepared abutment tooth.

The Class IV removable partial denture is indicated only where the edentulous span is too great or the position and forms of the abutment teeth are incompatible with the construction of a fixed partial denture. This is true, frequently, when one or both cuspids are missing. The extension of the base over the labial ridge is determined by the loss of tissue, by the amount of recontouring which must be done for the lip, and by the contour of the alveolar process and gingival tissue over the anterior abutments.

Some dentists advocate cast-metal bases for Class I and Class II partial dentures.[5] They believe that the transmission of thermal changes to and from the ridge tissues offers stimulation or eliminates certain processes which cause further resorption of the bony ridge. This seems to be an empirical assumption. Regardless of the material used, ridge tissue resorbs and removable partial dentures must be relined or rebased. Research has not demonstrated an infallible rule for determining which patient will be most receptive to a given denture-base material.

TOOTH SELECTION

The teeth used in partial denture construction must be of a material compatible with the occluding surfaces which are to oppose them. We use plastic teeth whenever possible, because we consider that they reduce both shock to the tissue and resorption of bone. Hughes[9] maintains that plastic teeth are less efficient than porcelain teeth, and, consequently, the patient chews with more vigor so that the resulting stress load is approximately the same. Many patients have had replacement partial dentures constucted with plastic teeth or plastic teeth with metal occlusal surfaces. These patients comment that there seems to be less shock upon contact than was experienced when their dentures supported porcelain teeth.

If the opposing occlusal surfaces have been rebuilt with metal, ground porcelain teeth cause rapid and unsatisfactory abrasion. Resin does wear, and rapidly in some instances. Metal occlusal surfaces opposing metal restorations are satisfactory, provided the opposing metals are of the same type and of a comparable hardness. The area of the occlusal surfaces of the supplied teeth should be reduced buccolingually, and the teeth should be shaped so that rounded, ball-like surfaces oppose similar surfaces or relatively flat cusp planes. In this way, food can be masticated rather than mashed, and the force induced by mastication is less than that resulting from crushing. Clinical observation points to less ridge resorption and less frequent relining or rebasing when the buccolingual dimension of the food table is reduced. Such construction is axiomatic in fixed partial dentures, and the same reasoning applies to clasp-retained removable partial dentures.

FINISHING THE DENTURE

Grunewald[10] demonstrated that open flask packing of dentures results in less distortion of the denture base and tooth movement than when the injection method is used. He advocates, also, the removal of a small quantity of the base material from the flask, instead of the addition of slight excess of material before closing. This is done to assure a better fit of the base and less change in the occlusion. It works. Before the cured denture is removed from the master cast, it should be returned to the articulator and the occlusal surfaces of the artificial teeth equilibrated. After the denture has been polished *without* touching the occluding surfaces, the occlusion is balanced as perfectly as possible in the mouth.

All natural teeth are polished and treated with stannous fluoride as a preventive measure against future caries, and this procedure is repeated at the periodic recall examinations. The patient is once again advised of the importance of regular examinations and the probability of the future need for relining or rebasing.

The patient is instructed to return 24 hours after the denture is inserted. A more extended range of mandibular movement usually is possible at this time, which aids in a more thorough equilibration. If traumatic occlusion can be demonstrated by the patient, the interferences are marked with articulating paper and corrected. He should be observed again within a few days.

Muhler,[11] one of the foremost dental authorities on diet and nutrition, states that the cortical and alveolar bone seems to be more prone to destructive forces after the teeth are removed than when the teeth and periodontal tissues are intact. He feels that proper nutrition is of extreme importance in the prevention of abnormal resorption of bone. Muhler does not suggest that dentists attempt to practice medicine, but that they should know what factors are imperative for establishing an "adequate" diet and be able to discuss such matters intelligently with the physician. He states that internists are available who can be helpful in advising our patients how to build up their resistance to ridge resorption without empirically planning a diet which could be detrimental otherwise.

RELINING

Class I and Class II partial dentures should be designed so that there are at least three widely separated stabilized points of contact. Two of these will coincide with the fulcrum line, and at least one must be anterior to this line of rotation to act as the third leg or point of tripod contact. If the partial denture has been constructed meticulously, these rests will be firmly in position in the rest preparations when the denture is in the mouth. After the partial denture has been worn for some time, it may be possible to produce movement or rotation around the fulcrum line. When this can be done, the anterior rest moves away from the rest preparation, which is an indication for relining the denture base. Indication of pressure on the crest of the ridge, such as tissue irritation, or a line across the retromolar pad also suggests the need for relining or possibly rebasing if the artificial teeth show abrasion.

We use a zinc oxide and eugenol impression paste for the reline impression, flask the partial denture, and add resin under pressure. However, there is much

to be said for Steffel's technique in which the borders of the base are reproduced in modeling compound and the impression of the tissue at the crest of the ridge is made with a nondisplacing impression material. Blatterfein[12] has published a comprehensive and sensible article relative to relining.

The relining process is not one in which impression material or self-curing resin is merely placed inside the denture bases, the partial denture seated in the mouth, and the patient asked to close with maximal force. Instead, the relining impression is made with the framework seated, so that all occlusal rests are in position with the mouth open. After the relining material has been added to the tissue side of the denture base, the denture is seated with the base in contact with the ridge and with the occlusal rests in contact with the occlusal rest preparations. If the relining has been done before an excessively long period has elapsed, little occlusal adjustment should be necessary. While the vertical dimension of occlusion may seem to be open at the time of placement, a 24-hour period of wear generally will find the opposing teeth, or the mandible, adjusted to the situation.[13] When the denture is observed at that time, minor occlusal adjustments will be needed, but however minor, they *must* be done.

The office recall system should apply to all patients, but particularly to removable partial denture patients. Their periodic visits should be more frequent than those of patients with fixed partial dentures. Prophylactic treatment must be especially thorough, and roentgenographic and periodontal examination should be all-revealing. The patient should be requested to observe his masticating efficiency frequently, to be able to answer intelligently all questions which may be asked pertaining to the comfort and successful use of the prosthesis.

CONCLUSIONS

1. Preservation of ridge tissue is the joint responsibility of the dentist and patient, but the dentist must be the leader in this accomplishment.
2. Preservation of ridge tissue begins with the planning of the removable partial denture.
3. Preservation of ridge tissue is abetted by mouth preparation.
4. The most important factors in preventing ridge resorption and in maintaining the health of the soft tissues are (1) adequate denture-base coverage, (2) reduced occlusal food table, (3) exactness in occlusal equilibration, (4) frequent examination and relining as soon as indicated, and (5) patient control through a persistent recall system.
5. Observation of these criteria in practice will reserve ridge tissue for complete denture construction in the event the "point of no return" should be reached.
6. The stipulations outlined by Metty have been met by this article.

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FIXED PARTIAL DENTURES

COMPLETE MOUTH REHABILITATION THROUGH FIXED PARTIAL DENTURE PROSTHODONTICS

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THE CONCEPT OF COMPLETE mouth rehabilitation is dependent basically upon three proved and accepted principles.[1] These are (1) the existence of a physiologic rest position of the mandible which is constant, (2) the recognition of a variable vertical dimension of occlusion, and (3) the acceptance of a dynamic, functional centric occlusion. These principles have been basic in the development of the myofunctional concept of mastication and have furthered the development of the physiologic concept of occlusion.

PHYSIOLOGIC APPROACH

The study and practice of complete mouth rehabilitation embody the utilization of the existing dynamic potential, as opposed to an unscientific, static approach to the oral mechanism. This latter concept professed an abstract understanding of the various component parts but failed to integrate this knowledge. Each part was regarded as an independent entity. The concept of dynamics embodies the correlation of all the component parts into one functioning unit. Therefore, the aim is rehabilitation of the whole, satisfying all the related factors. These include the health of the periodontium, vertical dimension, interocclusal distance, functional balanced occlusion, and esthetics.

The maxillomandibular relationships are not static but must be considered as a functional unit. Since muscular function and innervation work together in synchronous harmony, the approach must be physiologic.

FUNCTIONAL ANALYSIS OF OCCLUSION FOR DIAGNOSIS AND TREATMENT PLANNING

A functional analysis of occlusion is pertinent to effective diagnosis and treatment planning.[2] Each phase of the analysis will be discussed.

The proper vertical dimension of occlusion is determined by utilizing the physiologic rest position of the mandible as a guide. The existing interocclusal dis-

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tance is noted. In prosthetic treatment, whether it be for mouth rehabilitation or complete or partial denture construction, the dentist must have a practical and scientific approach to the problem of the interocclusal distance. Because the physiologic rest position is constant, the amount of interocclusal distance that is available in each patient can be determined.

The path of closure from rest position to the physical contact position of the teeth is examined. We palpate the temporomandibular joint area with the index finger and note the path of closure, whether displacement takes place, and whether there is tenderness and crepitation. We observe the excursive movements of the mandible, palpating the joint area to determine if the mandible is in a locked position, if it glides smoothly, or if there are interlocking cusps.

An analysis of functional occlusion must include the effects of the occlusal pattern upon the periodontal structures. Roentgenograms aid in studying existing intraoral conditions, detecting traumatogenic occlusion and bone destruction, and determining whether a good or a poor bone factor is present. If the bone condition is favorable and a poor occlusion exists, a favorable prognosis may be anticipated. If the bone factor is poor and there is concomitantly a poor occlusion factor, however, the prognosis is questionable. If a poor bone factor exists with favorable occlusal relationships, the prognosis is unfavorable.

Roentgenographic studies are made to determine the temporomandibular joint positions relative to the occlusal pattern. We employ a method of laminography for these joint studies. Exposures are made at the rest position, the physical contact position of the teeth, and the wide-open position. A double exposure of the physiologic rest position and the physical contact position is made on a single film to determine mandibular movement from rest position to the point of physical occlusion. If condylar displacement occurs, two distinct condyle positions are visible on the roentgenogram. This indicates that the balanced positioning of the mandible when it is at rest position is not maintained when the teeth are brought into occlusion and that the mandible is displaced by abnormal occlusal relationships. If a balanced occlusion exists, no displacement will occur and only one condyle position will be visible on the film.

THE IMPORTANCE OF A CONSTANT PHYSIOLOGIC REST POSITION

The physiologic rest position is a reliable starting point for the design of a physiologically correct occlusion.[3,4] It is a relaxed, normal, physiologically balanced maxillomandibular position. The antagonizing tensions that exist during function are in an equilibrated state. All functional movements of the mandible begin and end at this rest position. Techniques have been devised whereby this position can be recorded, registered, and maintained.

The interocclusal distance is that space existing between the physiologic rest position of the mandible and the tooth contact position. Therefore, as the vertical dimension of occlusion decreases as a result of loss or wear of teeth, the interocclusal distance increases. Consequently, the mandible must travel a greater distance than normal for the teeth to make positive contact which results in the activation of abnormal, unbalanced forces. Conversely, if the physical contact position

of the mandible is at the rest position, or if it is in a functioning position beyond the rest position, no interocclusal distance exists. The mandible must travel an excessive distance beyond the rest position during the process of mastication which results in abnormal tension on the musculature and undue forces upon the teeth and the supporting structures. The strain and pull on the muscles might produce pain, discomfort, and constant tension. The muscles will return eventually to their normal length, but only after detrimental changes occur in the oral cavity. The return of the strained musculature to normal length may cause resorption of the underlying alveolus, resulting in possible loosening and migration of teeth.

CORRECT VERTICAL DIMENSION

Vertical dimension can be described best as the vertical height of the face. It is determined by muscular relationships, utilizing the physiologic rest position of the mandible as the guiding factor. Therefore, a practical knowledge of the physiologic rest position is essential in the determination of correct vertical dimension of occlusion.

Since the mandible assumes its positional relationships to the skull early in life, the vertical dimension of the face is established necessarily at that time and remains proportionately constant throughout life.[5] Therefore, treatment of a reduced vertical dimension is not designed to increase the vertical dimension beyond the normal, but is intended to restore the amount of vertical dimension that has been lost. In rehabilitative procedures, the masticatory organ must be reconstructed within the limits of the physiologic rest position with sufficient allowance for a functional interocclusal distance. The interocclusal distance varies with the individual problems presented and is dependent upon various factors. Some of these are the age of the patient, the amount of lost vertical dimension, the condition of the periodontium, the extent of malocclusion, etc.

THE INTEROCCLUSAL DISTANCE AND ALTERATIONS IN VERTICAL DIMENSION

An adequate interocclusal distance is necessary for proper speech and mastication. Careful consideration must be given to this problem. Roentgenographic studies[6] have determined the interocclusal distance to be close to the assumed value of 2 mm. for most patients. However, the exact amount should be determined for each individual. The greater the decrease in the vertical dimension, the more interocclusal distance should be allowed. Also, a younger person will tolerate a greater increase in the vertical dimension and will become adjusted more easily to a reduction in the interocclusal distance as necessitated by new changes.

The physiologic rest position less a sufficient deduction for the interocclusal distance results in the proper vertical height. There are several methods used to obtain this position. We use the principle of tiring the depressor muscles of the mandible. When these muscles have been tired sufficiently, the mandible will assume its rest position. The patient is seated upright in the chair with the body and head in a perpendicular relationship to the floor and with the mouth empty. The patient is instructed to keep the mouth open wide until there is a noticeable quivering of the orbicularis oris muscle. Usually, this quivering may be noticed in 3 to 5 min-

utes. The patient then closes the mouth, swallows, and relaxes. The quivering of the lips is a fairly sound indication that sufficient tiring of the depressor muscles has been achieved When the depressor muscles have relaxed fully, the mandible will assume and maintain the rest position for an indefinite length of time. Measurements recording this position can be made repeatedly and will be constant.

THE MYOFUNCTIONAL APPROACH TO CENTRIC RELATION AND CENTRIC OCCLUSION

The position that the mandible assumes when the teeth are brought into occlusion is the physical contact position. This position is determined by the interrelationship of the cusps and inclined planes of the opposing teeth. In a normal occlusion, the physical contact position corresponds with centric position of the mandible. This is a static relation of the mandible to the maxillae, determined by the cuspal relationships of the mandibular to the maxillary teeth. It is the midway point in the "centric cycle" which consists of the movement of the mandible from the physiologic rest position to the tooth contact position and back to the rest position. Therefore, centric occlusion may be defined as the occlusal interrelationship of the opposing teeth when the mandible is in its utmost state of closure.

An occlusion is an ideal centric occlusion when the opposing teeth intercuspate properly at an acceptable vertical height with an adequate interocclusal distance and when no condylar displacement occurs as the mandible travels from centric relation to centric occlusion.[7] A state of harmony must exist between the centric relation of the mandible and the centric occlusion of the teeth. In this ideal state, the teeth, the articulation, and the supporting musculature are in a perfect state of reciprocal balance. Consequently, all functional excursive movements are performed efficiently with coordinated and balanced synchronization. Deviations from this functional pattern result in a disharmonious relationship between the teeth in function, the temporomandibular joint relationships, and the supporting musculature. An abnormal path of closure develops, mandibular displacement occurs, and the mandible assumes an abnormal or accommodating position. Thus, the entire pattern of mastication lacks proper coordination and harmony.

Centric relation is a consideration of the maxillomandibular relationships, dependent upon myofunctional conditions. Centric relation is concerned with both the horizontal and vertical relationships of the mandible to the maxillae and may be recorded, registered, and maintained. With this myofunctional registration as a guide, the pattern of centric occlusion may be established. Centric relation can be recorded and registered only with an understanding of the dynamic balance of the muscles involved and of the forces and stresses being constantly activated.

Centric relation is that position of the mandible in relation to the maxillae when the condyles are balanced properly in the glenoid fossae as a result of proper muscular balance. It is generally agreed that centric relation is indicated by the apex of the Gothic arch (needle-point) tracing, which is a recording of mandibular movements in various paths of function. However, modification of this concept is necessary. It is possible to obtain these tracings with instrumentation that does not take into account the functional aspects of mastication. Hence, the apex of the

tracing does not represent the true functional relationship. This position may represent a balance of the muscles operating in only one plane. In order for a needle-point tracing to be representative of the true functional relationships of the mandible to the maxillae, a balance of the forces constantly operating in both the horizontal and vertical planes must be obtained. If the centric relation record does not reflect a true balance of the muscles and forces involved, functional requirements will not be satisfied and the centric position and occlusal pattern will not result in a functionally correct occlusion.[8]

Since the stresses applied by the musculature are responsible for positioning the mandible at rest as well as in function, harmonious balance of the muscles must be secured. Until recently, the consideration that the muscles are the basic guiding factors for establishing centric relation, as well as the vertical dimension of occlusion, was ignored. It was believed that a proper contact relation of the teeth would satisfy all requirements. Centric relation is concerned with the myofunctional relationship of the mandible to the maxillae, and centric position is concerned with teeth in occlusion. An accurate centric position results from a correct, functional centric relation when a balance of the muscles has been obtained.

The two basic movements of the mandible are (1) rotation around a horizontal axis which passes through the center of the condyles and (2) a sliding or lateral movement of the condyle and interarticular disk along the temporal bone. Thus, there are in constant operation forces activated both in a horizontal and vertical plane. True centric relation is concerned with a balance of these operating forces.

GUIDING PRINCIPLES IN RE-ESTABLISHING OCCLUSION

The plane of occlusion is established employing the following factors as guides: (1) the type and severity of the jaw relations, (2) the extent of the interocclusal distance, (3) the inclination of the teeth, (4) the incisal guidance, (5) the clinical crown-to-root ratio, and (6) the functional excursive movements as transferred to the articulator.

The interocclusal distance is divided so that a uniform restoration is achieved on both the maxillary and mandibular dental arches. A favorable clinical crown-to-root ratio must be maintained. An excessive increase in the clinical crown length may create abnormal leverage upon the supporting structures of the tooth. As a general rule, the maxillary six anterior teeth are carved initially to assure esthetic appearance. This is followed by the carving of the mandibular incisor teeth. Next, the maxillary posterior teeth are carved into the indicated occlusal plane and curve, and, finally, the mandibular posterior crowns are waxed into occlusion. The occlusal pattern is adjusted according to the patient's mandibular excursive movements, utilizing the Pantographic Mandibular Recorder.[9] This assures the establishment of an effective balancing and functioning occlusion.

The width of the occlusal table is an important consideration. An occlusal table that is too wide will not divert the forces along the vertical axis of the teeth, which increases the possibility of abnormal torque. An occlusal platform that is too narrow will not provide equal distribution of forces because it is impossible to achieve coordination between the balancing and the functioning sides. The width of the

platform should be sufficient to restore the anatomic contour and distribute the occlusal forces along the vertical axis of the teeth. The crowns are contoured to provide sufficient tongue space and adequate space in the buccal vestibule. The occlusal form and cuspal detail are reproduced to achieve maximum functional efficiency and stability. Anatomically, the cuspal relationship is constructed so that occlusal forces will be directed along the vertical axis of the tooth.

An attempt is made to restore as much of the anatomic detail of the teeth as possible. However, certain governing factors control the extent and limitations of this detail. Factors such as age, the condition of the bone, the type of occlusion, the interocclusal distance, and the ratio of the clinical crown and the clinical root are important considerations.

PERIODONTAL CONSIDERATIONS

Improper restorative technique is a basic, causative factor in initiating periodontal disease. Restorations must comply with rules dictated by operative, periodontal, and mechanical specifications. A number of factors must be considered to satisfy periodontal requirements. Some of these are (1) proximal contact relationships, (2) crown form or contour, (3) occlusal and interproximal embrasures, (4) gingival margins, (5) occlusal relationships, and (6) finish and polish of the restorations.

Improperly formed contact areas are often the etiological agent in periodontal disease. Positive contact relationship is necessary to maintain tooth stability and position. The improperly formed contact area, or its complete absence, results in periodontal disease with inflammatory and destructive changes not only to the interproximal tissues, but to the deeper, underlying structures. Contact points will suffice for the anterior teeth and will protect the cone-shaped interproximal papillae. Contact areas are necessary, however, for posterior teeth to protect the broader, interproximal papillae. The contact area should lie immediately below the marginal ridges of adjacent teeth and be formed to create adequate occlusal and interproximal embrasures. Plunger cusp action of opposing teeth upon the occlusal embrasure must be avoided or the wedging action may cause spreading of adjacent teeth. The contact relationship thus serves to protect tissues of the interproximal embrasure and also prevents traumatization.

Crowns must be contoured to provide an anatomic form to the individual tooth. The occlusogingival tapering of crowns to establish buccal and lingual interproximal sluiceways is an important consideration. This serves to prevent horizontal food packs, fosters self-cleansing, and allows for mechanical stimulation by the patient. The restored surfaces must reproduce the shape and contour of the natural teeth.

Overhanging gingival margins cannot be tolerated by the periodontal tissues. The results are engorgement and enlargement of gingival tissues with eventual periodontal pocket formation and breakdown. Roentgenographic study of the margins of all restorations to detect faulty crown-to-tooth relationships is essential. The gingival margins of all full crowns must be extended beneath the free margins of the gingival tissues 0.5 to 1.0 mm. This procedure prevents possible decay, assures mechanically sound restorations, and satisfies esthetic requirements.

Restorations must be highly polished and have nonirritating surfaces. Failure to restore proper contour, effective margins, and adequate polish will result in irritation to the tissues of the embrasure and cause periodontal disease.

The importance of establishing a sound, physiologically balanced occlusion is basic. Harmonious occlusal relationships foster the health of the periodontium. Through restorative dentistry, it is possible to re-establish a balanced occlusion which will operate harmoniously within its environment.

REHABILITATIVE PROCEDURES UTILIZING MULTIPLE SPLINTING

The splinting of teeth into a fixed unit for their mutual support is invaluable in the treatment of the periodontal condition. Diminished periodontal strain and trauma upon the individual teeth are effected, stabilization and fixation of mobile teeth occur, and functional stresses are distributed uniformly. Splinting is a biologic procedure. Individual tooth movement is not obliterated by splints and fixed restorations, but the forces are directed so that the entire periodontal membrane is stimulated fairly uniformly. By means of splinting, the individual teeth appear tighter because the splint distributes the supporting force of the tooth more uniformly. There is not as much movement by any part of the tooth-supporting membrane as there was prior to the splinting. The general biologic principles of splinting are (1) a reduction of periodontal strain with a resultant tightening of the teeth and (2) a physiologic reorientation of tooth movements from pathologic tilting to stimulating vertical body resistance.

In the application of the splinting principle, the construction of a continuous splint from a molar on one side to a molar on the opposite side is not indicated. The span of the splint should be limited. For example, in splinting a full complement of teeth, three splints would be employed with the first unit extending from the second or third molar. At times a precision lock is placed at the cuspid and first premolar contact. Limiting the length of the splints reduces the possibility of abnormal torque, assures proper seating of the individual units, and facilitates changes if necessary.

SUMMARY

Our approach is a biologic and functional one, with the masticatory unit being considered as a functional, consolidated unit. All functional factors are interrelated, and in reconstructive prosthesis, proper regard for each aspect is essential if the restoration and maintenance of the health of the entire functioning organ are to be realized. All our efforts are directed toward re-establishing a state of functional efficiency in which the teeth and their periodontal structures, the muscles of mastication, and the temporomandibular joint mechanisms all function together in synchronous harmony. The object of complete mouth rehabilitation must be the reconstruction, restoration, and maintenance of the health of the entire oral mechanism.

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PRINCIPLES INVOLVED IN RESTORING OCCLUSION TO NATURAL TEETH

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OUT OF THE EXPERIENCE gained in restoring occlusion to natural teeth has come an awareness that there are certain underlying treatment principles. These principles are so important that they cannot be overemphasized. The origin and the crystallization of these observations can be appreciated best, perhaps, by showing how the practice of oral rehabilitation has grown up while being applied.

For nearly half a century, dentists have been trying to make total occlusal restorations on the natural teeth. The pioneer dentists who worked simply in this complex organ were not as conscious of the importance of the multitude of factors as dentists are today. Consequently, they often committed unintended violence by unwittingly transgressing the periodontium, the joints, and the muscles.

CENTRIC RELATION

Since these pioneer dentists worked on the teeth, they naturally believed them to be the most important part of the mouth. They taught, and had been taught, that the teeth should be the guides for mandibular positions and the chewing strokes. They defined centric occlusion as if it were independent of condylar position. They did not hesitate to use the occlusal restorations to force the closure of a retrognathic mandible forward, for they had been assured by their teachers that the far-away joints were adjustive and adaptive and would "catch up" with whatever was done to the teeth. In practice, however, they learned that a protrusively forced closure made the teeth "loose" and "sore," or it moved them, caused them to wear faster, or sometimes made the joints ache. These unwanted results made some of the pioneers conscious of the importance of centric relation. Today, there is a consensus of opinion that the mandibular centric relation is a constant in the individual and that it is wise to conform restorations to it.

Why Centric Relation?—Experience with balanced occlusion has taught that unless the maximum intercusping of the teeth is coincident with centric relation of the mandible in the terminal hinge closure, restorations will not work in the mouth as they did on the articulator. Likewise, in a mutually protective occlusion, the tooth relations on the articulator will not be the same in the mouth unless the opening-closing hinge and centric relations are the same on the articulator as in the patient. Many fear that centric relation may cause the development of occlusions that

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are "too far back." The onlooking critics can dismiss their fears, because holding the terminal hinge intercusping position is the dentist's most difficult problem. Preventing the forward intercusping of teeth is one of the main objects of treatment. Any mislocation of the true opening-closing axis in its posterior position, when transferred to the articulator, produces radii of movement that are different than those of the mandible.

Another principal objective of treatment is to give the mandible freedom to reach the border limits of movement, without any cusps preventing it at the level of tooth contact. There seems to be a fear of having patients move the mandible to the limits of border movements and positions. The occlusion of the teeth is a border limit whether the mandible is in its centric relation or eccentric positions. We believe that the mandible should be allowed to reach all its border limits freely without any restrictions by cusp interference.

VERTICAL DIMENSION

Originally, to gain ample space for the planned restorations, splints were put upon the posterior teeth to train the jaw and the joints to an increase in vertical dimension. Because of such practice, restoring occlusion was known as "bite-opening." The pioneers were disturbed to find that restorations which increased the vertical dimension of occlusion caused the patient to have lingering complaints. They had never heard of the interocclusal space and its alleged constancy in the individual. It was hard for them to believe that the pains in temporomandibular joints and weariness in the muscles of mastication were real. They just could not believe that an increase in the vertical dimension which improved the patient's appearance could be so disastrous to his comfort. Even today, a dentist may send a patient he has treated to a psychiatrist to evaluate the validity of complaints of temporomandibular joint pains.

CUSPS

Are Cusps Important?—As the skilled dentists struggled to restore occlusion more accurately, they found that they could not give it organization or make the restorations look like human parts without recreating cusps. They saw that there is a vast difference between the crude process of armor-plating worn-off teeth with gold and the orderly integration of restored cusps. Flat-surfaced restorations, aside from being ugly and difficult to keep from wearing away too rapidly, are but pathologic shapes frozen into gold. They are unworthy of the skill that the modern dentist can muster. Scoffers at accurate dental work have uttered sarcasm against the emphasis put upon restoring cusps, but there is no way whereby occlusal restorations can be integrated except through cusps properly made and placed. By their graduated heights and sizes, they can be coordinated with the closing arcs of the mandible. By their suitable placements, they can be coordinated with condylar thrusts. By occluding most of them, each into a receptive fossa of an opposing tooth, the dentition can be given comfortable vertical centric occlusal interlocking. By good coordination with the chewing movements, the blades and ridges of the cusps can be set to cut food and, yet, not rub and wear each other. Thus, by means

of cusps, the dentist can give organization, function, stability, and beauty to the dentition.

Black's Observation.—As early as 1886, G. V. Black looked upon the formation of facets that grow into large, flat occlusal surfaces as a disastrous, abnormal result. He speculated about the need to restore cusps "at suitable points" to prevent (by their interlocking) ruinous gnashing. He saw no technical way of doing this, but thought that it would be well worth while to restore cusps if it were possible. He suggested that the involved diagnosis would be uncertain. He apparently recognized that dentistry, then, had neither the knowledge nor the instruments to make the preliminary functional examinations and diagnoses. It can be said, however, that Black understood that good occlusion cannot be had without cusps.

Post-Black Dental Era.—In the early years of this century, two important dental developments took place and each contributed toward making it possible for dentists to do what Black had wanted to do, namely, restore cusps. One development was purely technical, the other was both technical and scientific. The former was started by Taggert, who gave us the simple principles of casting gold forms from wax patterns. The latter was initiated by Gysi, who popularized the study of mandibular movements. It was impossible to make integrated occlusal restorations out of gold foil or amalgam or by using shell or standard crowns. It would still be impossible for dentists to coordinate cast cusps to the peculiar, individual jaw motions of a patient without using an accurate mandibular movement recorder. In the post-Black era, it was the study of the movement of the mandible of the living human that led to the development of recording instruments. This study has given to dentistry a better understanding of the best functional relations of the parts of the oral organ. Year after year, by restoring in treatment what was considered the best working relations of the teeth and then observing the results, clinicians formed judgments of practice which, when substantiated by science, became the principles of treatment.

ARTICULATION

Overemphasis Can Be Neglectful.—Many geometric formulas have been developed for recreating occlusion through the use of triangular and spherical principles. Some of these principles disregarded the movements of the condyles as factors in reconstructing occlusion, others propounded frozen formulas, and others developed statistical averages. But the person being treated is not a statistical average—he is an individual. There is no one else in the world who has his exact dimensional relations.

Less geometrically minded dentists could not believe that the dental factors of articulation should dominate, arbitrarily, all other factors of oral dynamics. They could not wish away the influence of the condyles. They could not theorize the condyle paths out of existence. Nor could they, by cultish exorcism, banish the joints from their seats of sovereignty, because every now and then the wrath of the violated joints caused so much pain to the patient that the too arbitrarily made restorations had to be removed. From such extremes, dentists have learned that

overemphasis on one set of articulative factors is quite likely to cause a corresponding neglect of other, equally important factors.

Nonviolence Principle.—As knowledge of oral physiology grew, a more moderate view of the relative importance of the factors of dental occlusion emerged. The application of this view entailed the ways and means of making cusps and condyles cooperate so that neither set of factors dominated the other. This concept of placing cusps on teeth so that they could work smoothly, and be well geared to the axes of the condyles, was developed on the reasonable belief that occlusal restorations need not be violent to the teeth, the periodontium, the joints, the muscles, the tongue, or any other part of the oral structure. If pain or discomfort follows restorations, if the gums bulge into the embrasures or if they recede, if the periodontium in the socket thickens, if eating is awkward, if the mouth becomes weary, or if the patient remains overly conscious of his restorations, this principle of nonviolence has been overlooked to a harmful degree.

Consideration of All Factors.—To many students of occlusion, it seemed logical to assume that the least violent arrangement of oral parts would come from an articulation of cusps in which there would be both bilateral and protrusive balanced occlusion. They held that this classic and revered collective tooth arrangement, in which all the teeth work together in nearly every biting station, would afford a stability because the muscles would strain neither the teeth nor the joints and could not overburden teeth singly. Restoring balanced occlusion to natural teeth became more nearly possible after an articulator was made that would reproduce accurately the dynamic and static interocclusal and odontocondylar relations of the patient. For upon such an instrument set by the data collected from the kinematic face-bows, the diagnosis could be made and the treatment prescribed. The teeth could be prepared as would be directed by the diagnosis. The remedies could be fabricated under continuing diagnosis. Casts copying the tooth preparations could be transferred to the set instruments and the restorations could be processed, refined, and carried back to the patient to be tested. With adequate care, no intraoral adjustments may be necessary to make the remedies receptible to the conditions considered best to meet the patient's requirements. This can be done successfully because all the factors of jaw relations are duly reproduced in such instruments and are given proper consideration in the treatment.

BALANCED OCCLUSION

Balance Based on Centric Relation.—The success of restored occlusion has been judged by how well the teeth close in centric occlusion, how well they balance laterally and protrusively, how well they balance bilaterally, and how well the balancing cusps engage. If the teeth passed these tests, the examiner would know that the total setup of the cusps was identified with that basic jaw position called centric relation. Such balanced occlusion cannot be attained if started from a mandibular occlusal position not centrically related. If started from an eccentric mandibular occlusal position, certain cusps, or most of them, would enter into unwanted guidance of mandibular movements, and it would not be long before they would become facet-worn. It was the disregard of condylar positions in setting up the teeth that led

dentists to believe that the teeth should guide mandibular movements and "wag" the condyles. Balanced occlusion, when achieved, exemplifies a complete coordination of the dental factors with the condylar factors. Balanced occlusion is an integration of cusps of such a character that they are utterly denied the role of any jaw guidance. Although based upon centric relation, cusps in balanced occlusion would not guide the jaw to centric position; the jaw muscles and the condyles provide such guidance.

Balance Without Increased Vertical Dimension.—Balanced occlusion has often been associated with an increased vertical dimension of occlusion. As diagnosis and treatment improved, the most conservative dentists found that, in many patients, they could gain enough space for sturdy, correctly related cuspal restorations by judicious tooth preparations *without altering* the vertical dimension. Dentists may not know now how much or how little, proportionately, the vertical dimension can be changed without violating the well-being of the dentition being restored. This seems to be true because the practice of increasing the vertical dimension of occlusion derived much of its unfavorable reputation from harmful factors with which it has often been associated. These are "bite-jumping," irregular, incoordinated flat-top restorations, restorations confined to the molars and bicuspids, and overbalanced conditions. In distal malocclusions with a deep vertical overlap, the dentist, in order to gain protrusive balance, would use restorations on the bicuspids and molars tall enough to keep the anterior teeth out of occlusion. This created a very unstable centric occlusion. This compromised balanced occlusion has instability in its mechanics. The remedies are intrusive appliances which are put upon teeth that have already been subjected to intrusion. As the restored molars and bicuspids undergo further intrusion, they tend to lean forward and jumble the anterior teeth which had been taken out of occlusion. The movements and the intrusion cause imbalance and prematurities. Schweitzer[1] has written an extensive summary of all the ills that result from tampering with the vertical dimension. As a general principle, it would have been far better to forego attempts to provide protrusive balance than to overincrease the vertical dimension. Any change in the vertical dimension of occlusion, either an increase or a decrease, should be minimal.

The Hopes Held for Balance.—Dentistry had held high hopes for balanced occlusion until it could be time tested in natural dentitions. Many "restorers" of occlusion have considered balanced occlusion as a restorative necessity. If it was absent or not complete in a treated dentition, they regarded the treatment as unrestorative. They believed that balanced occlusion would be highly accepted by patients, that it would save the teeth and secure the stability of the dentition, and that it would spare the periodontium from strains. They presumed it would provide esthetics and good function. Therefore, they thought the patients would like it, that the teeth would not wear away because the abrasion would be so generally distributed, and that it would stabilize the teeth in their arches because there could be no cusp conflicts to drive the crowns about to dislodge them. These were the arguments put forth to bolster the faith in balanced occlusion, for long-lasting, stabilized dentitions have been the greatest desire of dentistry.

Troubles From Balance.—Balanced occlusion, as it has been applied to complete dentures, had to be readapted for bone-anchored teeth. It had to be changed by reducing the number of cusps involved in the balancing, by lessening the height of the lower lingual cusps, by reducing the edge-to-edge contacts of the buccal ridges in the lateral mesh, and by increasing the roundness of the occlusal surfaces of the cusps. On the balancing side, the bicuspids were the first to be removed from balancing contacts; later the balancing contacts of practically all teeth were so reduced that the opposing balancers did not touch, but were merely adjacent. On the working side, the lower lingual cusps were taken out of enmeshment by reducing their height. Cross-mouth and cross-tooth balancing was eased to make chewing less awkward. The occlusal surfaces and the buccal marginal ridges were given more roundness to provide running, point-contact articulation which, supposedly, would delay the inevitable wear that comes to all teeth and restorations. Many patients could accept tooth-borne balanced occlusion without these modifications, but since it offended a sizable percentage of those treated, it seemed unwise to apply it even to those brave enough to tolerate it.

Balanced Occlusion Is Not Stabilizing.—What had been most expected from balanced occlusion was the stability it would give to the dentition in tooth structures and tooth positions. The ability of balanced occlusion to maintain the stability of dentitions has been disappointing. Soon after the restorations are inserted, small facets of wear appear; these enlarge into planes, related ridges are destroyed, and ultimately the cusps are effaced. As the occlusal surfaces wear away, the teeth shift from the original positions. In time, the occlusal mandibular position changes from that of centric relation. Prematurities develop in the lateral as well as in the centric occlusion. Hyperocclusion may develop on the balancing side to join with other prematurities in putting strains upon the periodontium, and in some patients these disturb the joints of the mandible and cause excruciating pain. The great lesson dentists have learned from observing restored occlusions as they wear out is that "natural wear" is not so beneficial or so balancing as dental writers once fancied.

Role of Emotions.—If persons used their teeth only for chewing, wear would be slight because the cutting blades would scissor past each other without frictional contact and the end-on-end centric collision of the posterior teeth would take place without much effacement. Chewing of modern foods, for the most part, is vertical. The lateral mandibular actions seen in a person while chewing are made largely to tumble the bolus, not to rasp the teeth horizontally. But tense persons may express deep emotions by gnashing their teeth. If the occlusion is strange, by being too full or too high or eccentric, patients will "play" with it. They will test the rough spots or the high spots or the prematurities by biting horizontally upon them. In disturbed sleep, certain persons may grind their teeth violently. The emotional activities of the mandible are likely to be more nearly horizontal than vertical. Balanced occlusion does not prevent these sliding movements. Indeed, one of the reasons why teeth are balanced is to permit ready horizontal articulative movements.

Balance Promotes Wear.—A study of naturally acquired balanced occlusion rather suggests that it is an arrangement of teeth that predisposes them to rapid

wear. If the patient glides his teeth for any reason, the lower buccal cusps and the upper lingual cusps are abraded on both their lingual and buccal slopes. In the case of a lower buccal cusp, its buccal slopes wear when "working" and its lingual surface wears when "balancing." In bruxism, it is probable that the abrasion can occur faster than can be compensated for by the constant extrusion of the teeth. The resulting reduction of the height of the cusps could reduce the vertical dimension. The lower lingual cusps and the upper buccal cusps get a one-sloped reduction; hence pointed relics of them remain after the doubly ground cusps are gone. Such sloping relics are believed to cause an expansion of the maxillary arch and a contraction of the lower arch. While the buccal (posterior) teeth are being abraded, the anterior teeth become end to end and are worn down to stumps.

Balanced Occlusion Becomes Unstable.—Dentitions in balanced occlusion are readily upset in their relations. There are degenerative occlusion factors that destroy the balance. There are no dynamic factors that preserve it. The balance has no depth. The plane of the balanced state of occlusion is paper thin. With a little wear, the fine, hand-wrought occlusion becomes out of balance. Since rapid wear changes the vertical dimension, the lateral and mesial relations of the dentition are altered. The prematurities appearing in the lateral and centric closures tend to move the teeth out of gear, which further upsets their balance. Early in the observations of the prognosis of balanced dentitions, the dentists who made the treatments became concerned because the restored dentitions lost centric relations so soon. They had built balanced occlusion to gain stability. It did not guarantee equilibrium. Equilibration based upon attempted balancing of occlusion is of short duration.

Balanced Occlusion Provides No Spare Ridges.—In balancing a dentition by restorations, every created occlusal ridge is given full-running occlusal contact. No ridges are held in reserve for the future. Every marginal, oblique, or transverse ridge is set to enter the war of abrasion. Natural, well-occluded dentitions hold many ridges out of closure contacts, as if they are spares for the future. Even the lingual cusps of the upper bicuspids do not dip down fully into their opposing fossae until after adolescence. Such slowness in subjecting ridges to wear gives the natural dentition its ability to adjust itself functionally to the dimension of time. There is no way for a balanced dentition to adjust itself to wear. It is a doomed dentition from the start. The good natural dentitions that have lasted longest were never in a state of balanced occlusion. Simulated balanced occlusion in natural dentitions is usually a manifestation of disintegration. It shows that much wear has taken place. The teeth no longer have a centric occlusion. The flattened tops of the teeth become arrayed in irregular curvatures that are related to nothing but the accident of wearing unevenly.

NATURALLY COORDINATED CUSPS

In good, naturally coordinated dentitions, there is only one position in which all the teeth have contacts with opponents. This is in the centric occlusion which coincides with the rearmost position of the mandible. In lateral mandibular deflec-

tions, only the cuspids have opposition contacts. In the protrusive mandibular closure, only the upper six anterior teeth have opposition contacts with the lower eight anterior teeth. There are no lateral cuspal enmeshments and it is possible for the lower cusps to pass rapidly through a thick bolus of soft food all the way to centric occlusion, without making any contact with the maxillary teeth until they are finally stopped by the latter. The food is chopped by the buccal blades of the lower cusps passing closely by corresponding blades of the upper cusps. The incisors are set so that they can cut off food without maintaining running contacts. When the incisors are cutting off food, the posterior teeth are out of contact. When the person chews on a side, the front teeth and those on the opposite side of the mouth remain out of contact until centric occlusion is made. If teeth rub against each other in either lateral or anterior incisions, they are not in ideal coordination. The only balance the dentition has is in centric occlusion. In good, naturally coordinated dentitions, the tooth blades and the cusps are arranged for vertical chewing. They are integrated with the jaw movements so that a maximum of chewing is accomplished with a minimum of occlusal contacts. The relations between the upper and lower cuspids are such that lateral enmeshments are impossible.

Importance of Escape Grooves.—In chewing, the mandibular cusps should be able to ascend to their centric occlusal destination by moving not against cusps, but beneath the gables or grooves between the maxillary cusps. Cusps can be placed, contoured, and sized so that chewing can be accomplished without gliding contacts. The grooves between cusps are channels in which cusps may travel without collisions. The directions of these channels are determined by their circumferential relation to the vertical axes of the mandible. The cross grooves of the molar correspond to arcs drawn from the vertical axis on the side of the rotating condyle. The oblique grooves on the balancing side correspond to arcs described by cusp points at various radial distances from the same rotating condyle vertical axis. The central grooves between cusps correspond to the anteroposterior movements of the mandible. The groove-cusp relations have the greatest significance in centric closure, for this destination must be reached without cusp-groove guidance. Such a centric occlusion should be established and maintained by occlusal restorations in mouth rehabilitations.

Cusps and Condyles.—To keep condyles and cusps in peaceful coordination, many details of relations must be considered in reconstructing an occlusion. The cuspal points need to be located with reference to several factors, namely, the kind, nature, size, alignment, and rotation of the teeth in opposition. They must be located by judicious trial-and-error methods in the development of mutually reciprocal wax patterns. The paths of the cusp points not only describe the direction of the grooves in which they travel, but as the cusps are shaped, they wall the slopes of the grooves. The cuspal sides walling the grooves are contoured to suit mandibular arcs. The graded heights of cusps from front to rear are orderly expressions of the arcs of closure. The placement, contouring, and graded sizing of the cusps and the establishment of the direction, width, nature, and walls of the grooves between the cusps all would have to be grossly guessed without geometrically relating them to the axes and the condyle paths of the mandible.

PROTECTION OF OCCLUSION

In the balanced restorations, the cuspids have sometimes been left in an unreconstructed, out-of-occlusion state. Sometimes they have been trimmed down so that they would not interfere with the lateral meshes and protrusive balance. Too often, a convex lug of gold has been placed upon the lingual surface of the upper cuspid to make perfunctory contact with the lower cuspid. Such odd additions were made as if the human cuspids no longer have function, but are mere evolutionary relics. The cuspids, however, probably have the same potentials that they had primitively. One of their purposes is to prevent injuries to the buccal cusps from lateral enmeshments and also to prevent incisors from being cross scraped in lateral movements. In modern restorations of occlusion, the cuspids should be carefully restored to such forms and relations as will best protect them, the other cusps, and the bladed teeth. The cusps of the molars and bicuspids, by interlocking in centric occlusion, protect the anterior teeth. The anterior teeth, when closed in incisive position, protect the cusp points of the posterior teeth. This mutual protection is of utmost importance and should be treated with the utmost care. The concavity of the lingual surface of the upper cuspid should be carefully organized by shape and position so that its curved, intaglioed bottom and sides are concentrically outside the chewing cycle of the tip of the lower cuspid. The timing which is expressed in the concavity of the lingual surface of the upper cuspid is dependent upon the lateral condylar movements. For all we know, the lateral perimeter of the chewing cycle may be definitely tied with these condylar movements.

IMPORTANCE OF DIAGNOSIS

In this outlook upon restoring nonviolent, mutually protecting occlusal remedies to natural teeth, the importance of diagnosis must be emphasized because the dentist is going to do more for teeth than can be done by self-prescribing balancing. Self-prescribed balanced occlusion is that automatically derived in the articulation of the molars and bicuspids after the anterior teeth are occluded and the curves of Spee and Wilson are positioned. A careful mounting of the patient's dental casts should be made on an instrument that copies his mandibular movements, so that a diagnosis of the functional relations may be made by studying them in connection with roentgenograms. Reconstructing the occlusal surfaces of the teeth may lead to serious consequences beyond the realm of the teeth. The dentist cannot afford to make mistakes in such undertakings. In this diagnosis, attention should be given first to the relation between the mandibular occlusal position and centric relation. The relation in sizes and positions of the opposing arches when in centric relation should be found. The ability of the incisors to function protrusively without posterior teeth contacting should be noted to ascertain how they will cooperate with the height of the cusps of the molars. The cuspid relations should be scrutinized. The nature and the slant of the plane of occlusion and its accompanying curves should be studied to determine how the teeth may be best prepared. There should also be some mature judgment used to determine what, if anything, should be done to the vertical dimension.

SUMMARY OF TREATMENT PRINCIPLES

The principles of treatment will depend to some extent upon what is brought to light in the diagnosis. There are, however, certain principles of treatment that are universal. First, the restorations should not be a source of pain and discomfort. They should not be active orthopedic appliances. They should not transgress against the nature of the oral physiology or trespass upon or invade forbidden areas. The cusps should be integrated so that they will close in the mandibular occlusal position (centric occlusion) in centric relation; their placement should be such that they will avoid clashes in close chewing; the lower buccal cusps should have fossa depressions to close into centrically. The upper lingual cusps should fit centrically into the fossae. The cusp-fossa relation of the teeth in centric occlusion should be such that any lateral or protrusive movement of the mandible from centric occlusion will entail opening. Reversely stated, the ridges walling the fossae are so related to the ridges of the opposing cusp that the closing jaw will nest into centric relation. Therefore, centric intercusping will occur at the most closed relation of the mandible. Cuspid relations are then timed to engage in lateral and protrusive positions. The timing is regulated so that the lateral and protrusive rubbing of the bicuspids and molars is limited to a fraction of a millimeter; however, the opposing ridges are close enough to perform efficient cutting. The cusp-fossa relation provides not only the mesiodistal locking of the teeth in centric occlusion, but also provides the important buccolingual lock.

By shifting the interocclusal contact from the posterior teeth to the anterior teeth in lateral and protrusive closures, the jaw leverages become minimal. The cusps, in shapes, placement, and graduated heights, should bear proper relations to the axes of the mandible. The cusps should be so well placed, so well shaped, and so well sized that the muscles can operate the mandible without causing clashes between any two cusps or between any cusp and the condyles. There is no longer any valid excuse for a dentist to cause the patient, his muscular memories, or his possible periodontal proprioceptors to undergo a new training program in order to acquire an alerted awareness of the dangers that have been built into the occlusal surfaces of the teeth.

PROGNOSIS

The final aim of diagnosis and treatment is to make prognosis more favorable. What dentistry wants to do is to preserve the natural dentition and to make restorations that will not only be nonviolent, but will themselves last long enough to be worth while.

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AN EVALUATION OF HIGH SPEED IN FULL-COVERAGE PREPARATIONS

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FROM A PRACTICAL POINT OF VIEW, high speed can be defined as rotational speeds starting at 100,000 r.p.m. This is the beginning range of speed at which small cutting tools can be used efficiently with light pressure. As the speed is increased to what might be called the super-speed range, over 200,000 r.p.m., the primary advantage is in a further decrease of handpiece pressure. With current high-speed handpieces, torque is inversely proportional to the number of revolutions per minute, and a light touch is required to prevent slowing down or stoppage of the handpiece. This can be considered a safety feature, as excess pressure automatically stops the instrument.

ADVANTAGES OF HIGH SPEED

Diminished Vibration.—There are two ways in which vibration perception can be diminished. The first is to decrease the amplitude of the vibration and the second is to increase the frequency of the vibration. Frequencies of over 1,000 cycles per second are not readily detected by the patient. The amplitude of vibration generally decreases with properly designed equipment. The most annoying vibrations occur in the range of 100 to 200 cycles per second, and these are present when 5,000 to 10,000 r.p.m. are used. The 1,000 cycles per second range could be called the vibration barrier; it starts at 60,000 r.p.m.

Diminished Cutting Pressure.—This is made possible by the great increase in cutting efficiency at high speed. A comparison can be made to power steering in an automobile, in the sense that it makes for more pleasant going, with the provision that we do not lose the "feel of the road."

Reduction in Operating Time.—Increased cutting efficiency provides for a reduction in operating time.

Reduction in Tension for Patient and Dentist.—Diminished vibration and cutting pressure, greater efficiency, and decreased operating time all tend to reduce tension for both the patient and the dentist.

Reduction in Trauma to the Pulp.—The total trauma to the pulp is the sum of the thermal trauma, cutting trauma, and miscellaneous trauma such as pressure on the dentinal tubules, multiplied by the time during which these stimuli are active. A reduction of time will therefore reduce the total trauma.

Presented before the Greater New York Academy of Prosthodontics, New York, N. Y.

Ease of Removal of Old Restorations.—The removal of inlays, crowns, and bridges is made considerably easier with the efficient, nonskip use of carbide burs rotating at high speed. This advantage alone would serve to justify the use of high-speed instruments as valuable tools.

Elimination of Discs.—It is generally recognized and statistically demonstrable that discs are dangerous, since they have been associated with the possibility of accidental damage to the surrounding soft tissues. Proximal cuts can be made with burs with greater ease and rapidity than is possible with a disc, and without danger of skipping, binding, or soft-tissue damage.

PRECAUTIONS WITH HIGH SPEED

Providing a Copious Water Stream.—The most important consideration is the absolute necessity of providing a copious water stream to counteract the heat produced in cutting. The use of weak sprays or streams of water which are not aimed correctly may permit the momentary development of intense heat with disastrous consequences to the pulp. Powerful suction devices, if held too close to the coolant spray, may compete with the tooth and divert the spray before it can reach the tooth. In order to reduce the possibility of overheating the tooth, a double water stream is desirable. With a simple adjustment, both tubes of the Hanau Tri-jet unit* can be made to provide water instead of the separate air and water they customarily carry. The extra water stream can be aimed at a slightly different level than the first one in order to provide complete cooling of a longer cutting instrument. The extra stream of water is more desirable than a jet of air, since water is a better coolant and air may serve only to divert the stream of water.

Retraining of Tactile Sense.—With slow speeds, heavier digital pressure aids in tactile cavity orientation. With high speeds, any attempt at tactile cavity orientation results in rapidly continuing tooth reduction or damage to adjacent structures. Tactile re-education is therefore necessary in order to avoid possible tooth damage.

Operating in Areas of Poor Visibility.—Where visibility is poor, as for example on distal surfaces of upper molars, slower rotational speeds are indicated. With slower speeds, tactile sense is improved and cutting errors can be stopped safely, before serious damage results.

Operating in Areas of Close Proximity to the Pulp.—Involuntary movements of the tongue, cheek, or lip may cause serious overcutting in areas of close proximity to the pulp.

Removal of Decay.—When large burs are used to remove decay, slow speeds provide the tactile differentiation between carious and sound tooth structure. This is not possible with high speed.

Safeguards for the Dentist.—During cutting procedures, tooth or metal particles may be flung into the eyes of the dentist. When rotary speed is tremendously increased, danger from this source is correspondingly increased; glasses should be worn by the dentist for protection while operating. The possibility of transmission

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of disease from the patient to the dentist should be considered. This may occur when the dentist inhales the fine spray thrown off by rapidly revolving instruments, since the spray may contain elements of blood or saliva.

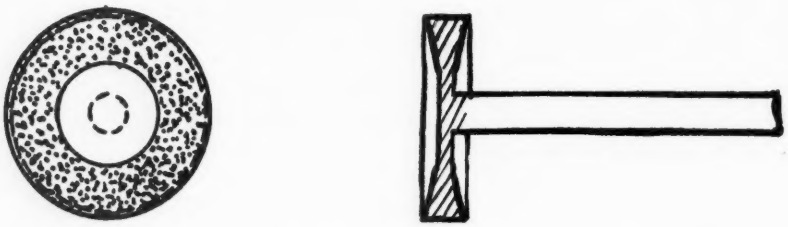

Fig. 1.—A cross-sectional and end view of the undercutting diamond wheel.

HIGH SPEED IN FULL-COVERAGE PREPARATIONS

While it is possible to prepare teeth for full coverage with small-diameter cutting instruments at high speed, it is a relatively tedious procedure. An undercutting diamond wheel[1] is available for removing the exposed surfaces of tooth enamel (Fig. 1). At speeds of 30,000 to 50,000 r.p.m., which can be obtained

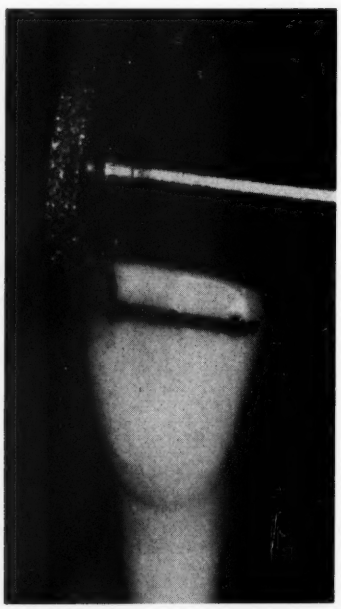

Fig. 2.—Incisal reduction of an anterior tooth with an undercutting diamond wheel.

readily with a straight handpiece, a 10 mm. undercutting wheel removes enamel far more rapidly than is possible with any other type of known cutting instrument at any available speed. In addition to its rapidity of cutting action, the step created by the wheel during the cutting process provides a perspective of the amount of

reduction taking place (Fig. 2). There is never any burning of tooth structure, because the water stream has a larger target to strike when it is aimed against the wheel and centrifugal force directs the water to the point of cutting action. A burning sensation or odor occurs sometimes with small-diameter burs or stones rotating at high speed. This results from the difficulty of aiming a water stream at a small target which may vary in length according to the size or make of instrument.

Reduction of the exposed enamel surfaces with the diamond wheel can be followed by the use of small carbide burs or diamond instruments. The cut surface thus produced is somewhat undulating and marked with horizontal striations that can be felt by running the edge of the fingernail over the preparation. Unless the striations are removed, they will impede the withdrawal of a compound impression.

Since carbide burs cut dentine very efficiently, they are difficult to control and overcutting is easily possible. Mastery of the instrument can be nullified by a slight movement of the patient's head, and a catastrophe results.

NEW CUTTING INSTRUMENTS

In order to further simplify the technique of full-coverage preparations with high speed, I have devised[2] a new series of carbide instruments* to be used after the initial enamel reduction with the diamond undercutting wheel. Fig. 3 shows some of these carbide instruments. Unbroken spiral blades of proper construction provide a smooth, glasslike surface on the preparation. Larger diameter and greater length of the cutting heads ensure smooth, flat surfaces where access is available. Chamfers or shoulders are produced automatically with a single instrument. Overcutting is impossible, because a safety edge at the gingival margin stops the cut automatically when it is completed. With the larger of these instruments, the recommended speed will range from 50,000 to 100,000 r.p.m. The smaller diameter burs still retain their full length and are useful interproximally, as well as for line angles.

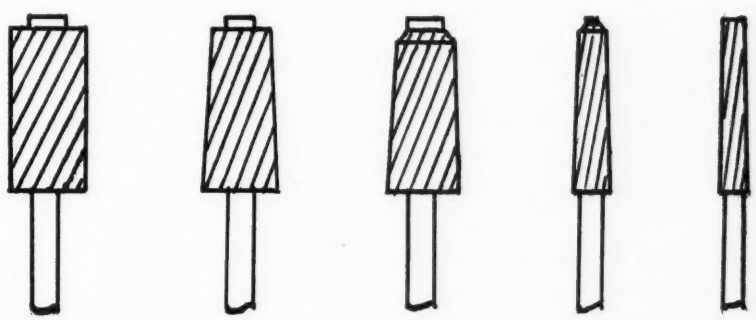

Fig. 3.—Some of the new carbide instruments. (From Leff, A.: High Speed Handpieces in Removal of Tooth Structure for Crown Preparations, D. Clin. N. America, March, 1959, p. 49.)

The super-speed, low-torque handpieces will function best with the small-diameter burs. This is essentially a limitation of this type of handpiece. The most

*Star Dental Manufacturing Co., Inc., 58th and Market Sts., Philadelphia 39, Pa.

desirable handpiece is one which can provide the proper speed and torque to utilize both the larger and the smaller burs for greatest efficiency and accuracy at each step in the preparation.

A chamfer or shoulder is a suitable gingival seat for a porcelain jacket crown. When a metal casting is to be fitted over the prepared tooth, however, a small apron or collar that extends beyond the chamfer or shoulder is desirable. This requires very little tooth reduction and can be accomplished with a small, tapered, cylindric diamond stone, similar in diameter to a 701 bur. Where a shoulderless preparation is used, this stone can be used also to extend the preparation subgingivally.

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PORCELAIN FUSED TO GOLD—EVALUATION AND ESTHETICS

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ALTHOUGH PLASTIC MATERIALS have been used universally as veneers, the material has never fully satisfied the needs of restorative dentistry. The dental profession had practically discarded porcelain after the advent of the plastic resins, but time and trial have proved that plastic is not the material desired and the pendulum is beginning to swing back to the use of porcelain. With this interest in porcelain reawakened, various porcelains to be fused on metals have become available.

The purpose of this project was to evaluate several of these metal-porcelain combinations. As a basis for this evaluation, the following requirements were considered:

1. The metal should be as easy to cast with the same degree of accuracy as standard dental gold alloys in the average dental office.
2. The metal should not oxidize or tarnish in the mouth and should possess good physical characteristics for dental use.
3. The porcelain should have the same coefficient of expansion and contraction as the metal to prevent its crazing or cracking upon fabrication. The porcelain should fuse within the range of 1,600° to 1,800° F.
4. The porcelain should be impervious to mouth fluids and dental plaques by a strong, condensed, and permanent ceramic glaze.
5. The colors should be stable and capable of esthetically matching the shades of the natural teeth.
6. The bond between the gold and porcelain should be strong enough to withstand the stresses and strains of the masticating forces.

METALS

The metals investigated were: A, Ney-oro P9; B, Jelenko P3; C-1, Permadent Permium 22 (yellow); C-2, Permadent Permium 22 (white); and D, pure gold alloyed with 10 per cent platinum. These metals will be subsequently referred to by these letters.

This investigation was supported by Research Grant D-596 from the National Institute of Dental Research, U. S. Public Health Service.
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Metal A.—The bulk of the casting work was done with metal A because of its ease of fabrication when using ordinary casting temperatures and investments.

Investment, casting, and soldering: Metal A can be successfully cast using the conventional gas and air flame and employing the same investments as are used for the typical dental gold alloys. In some instances, it was slightly sluggish and required a perfectly adjusted flame and more than average fluxing.

Soldering is somewhat difficult as compared to that with the average fixed partial denture restoration. Soldering rules as to cleanliness, correct heat, access, apposition of parts, etc., must be followed meticulously. The temperature range between the solder and the casting metal is narrow, but with care and experience, soldering can be accomplished without spoilage.

Accuracy of fit: The shrinkage of the molten metal can be compensated for with the same degree of accuracy as with the regular dental alloys. This ensures sharp, accurate margins and the desired amount of frictional adaptation.

Physical properties: The Brinell hardness number is 115 to 125. The elongation is 21 per cent, and the melting range is 1,880° to 1,930° F. The restorations should be designed to conceal as much of the metal as possible. Although the metal can be polished to a high lustre, it looks black in the mouth. This is particularly true where the metal reflects through the free margin of the gingival tissue.

Conclusion: Metal A possesses suitable characteristics and physical properties which make it usable for successful fixed partial denture work in the average dental office.

Metal B.—Castings were made to determine the bonding and esthetic qualities of various porcelain powders with metal B. Further tests were not performed, however, because the metal was too soft for successful fixed prostheses. This conclusion was reached because the Brinell hardness number is 47.

Metal C-1.—

Investment, casting, and soldering: Both Permavest investment and liquid as supplied by the manufacturer and also Kerr's Cristobalite investment were used. The Permavest was used according to the manufacturer's directions, and the castings were made successfully. Kerr's Cristobalite also was used successfully.

Better expansion was obtained by using the "double investment" technique. For this procedure the pattern is painted carefully with the investment mix and, when well covered, is dusted carefully with dry investment powder. By alternately applying the mix and dusting with the powder, the wax pattern is encased in a ball of investment which is invested in a regular mix.

Successful castings were obtained at the University of Oregon using Ransom-Randolph's hygroscopic investment in the proportion of 15 c.c. of water to 65 Gm. of powder. A double asbestos liner was used in the casting ring.

Metal C-1 cannot be cast with the conventional gas-air mixture. Although the manufacturer advocates the use of a gas-oxygen flame, better results are obtained with acetylene because of less danger of oxidation of the metal while heating. The formula of this metal is such that contamination and oxidation change the physical properties and tend to make the metal brittle and lessen the bond between metal and porcelain.

A separate crucible should be used for this metal, because of ease of contamination. An asbestos liner for the crucible should not be used. Soldering was easily accomplished with no distortion of the retainers by heating the restoration in the oven and soldering with the acetylene torch.

Accuracy of fit: Castings with metal C-1 can be made with accuracy, using care and special consideration to obtain maximum expansion. More than the average amount of compensation is necessary for this metal.

Physical properties: The Brinell hardness number is 90 and the melting range is around 2,200° F. Although designated as a yellow gold, metal C-1 is on the dark side, more toward a rose shade. Restorations should be designed to minimize the dark shadows when in the mouth.

Conclusion: There is some difficulty in handling metal C-1, and its physical properties do not make it suitable for fixed partial dentures. In selected situations, it could be used for an individual restoration.

Metal C-2.—Metal C-2 can be invested, cast, and soldered in a manner similar to that for C-1. The Brinell hardness number is 106 to 110.

Conclusion: Metal C-2 can be used for selected individual restorations. Its use for fixed partial dentures should be limited to short spans which are subjected to a minimum of masticatory stress.

Metal D.—Metal D was obtained by special arrangement with a manufacturer. It is difficult to cast metal D and obtain a good fit by ordinary means because of its high platinum content. The metal proved to be too soft for crowns even as a single restoration. A full veneer crown could be distorted by heavy finger pressure.

PORCELAIN POWDERS

The porcelain powders investigated were: I, Ney-oro porcelain; II, Apco low-fusing porcelain; and III, Permadent porcelain.

Porcelain I.—The bulk of the work done was with porcelain I. It was the only gold-porcelain system generally available without obtaining a franchise. Johnston[1] and others found that the porcelain-gold bond was good and that the porcelain had adequate strength.

The main problem was the one of esthetics. Our efforts to match a standard shade guide in the laboratory succeeded reasonably well, but clinically the porcelain had a dead appearance with a peculiar opacity when in the mouth.

At first, the various formulas, as suggested by the manufacturer, were followed to become familiar with the appearance of the various porcelain powders when fired to the metal. We hoped that this familiarization in manipulation would help us improve the esthetic result. "Esthetic improvement was not realized simply by varying the technique of porcelain manipulation."

The manufacturer's formulas for the body porcelain were applied over various shades of the opaque bake. The opaque porcelain powder was tinted by the addition of stains. Pink, light brown, yellow, and blue opaque powders were developed and fired to the castings. Tinting the opaque porcelain is of little or no aid in improving the appearance of the final product.

A shade guide was developed using the basic powders of porcelain I in various combinations and proportions. The idea was that this guide could be used clinically. We were able to reasonably duplicate the darker shades of older individuals without resorting to staining. For the lighter shades, however, staining was a requisite to obtaining a reasonable result for a restoration which was adjacent to natural teeth.

Fairly good results were obtained in complete rehabilitation where it was necessary to cover all the remaining natural dentition. Thus, we obtained a color continuity that allowed us to "paint our own picture."

We were more successful with the low-fusing (1,600° F.) S. S. White overglaze than we were with the overglaze supplied by the manufacturer. The supplied glaze seems to have a bluish-white appearance rather than being clear.

Porcelain II.—The manufacturer of metal B maintained that porcelain II, which is low fusing, could be bonded successfully to metal B. Examples of this porcelain fused to metal B were displayed. The esthetic qualities of this combination showed possibilities, if consistent results could be obtained.

We were not able to successfully fuse and bond porcelain II to metal B. All attempts resulted in immediate cracking and crazing.

Porcelain III.—All work with this material was done in the laboratory only. It was used on gold designated by the manufacturer, plus other alloys. We made no clinical tests of this porcelain.

Appearance, as compared with a standard shade guide, is good. Personal communication with ceramic technicians and dentists indicates that a pleasing appearance is obtainable clinically.

We found that the bond to the metal and the strength of the porcelain were not as good as with porcelain I. However, the material possesses enough bonding ability and strength to be usable clinically.

PERTINENT DATA

Specimens were both air fired and vacuum fired. There seems to be no advantage to vacuum firing. Phillips[2] found that the rate and degree of infiltration of radioactive calcium between the fused porcelain and the metal are greater when the specimen is vacuum fired. We found that vacuum firing changes the shades and necessitates new formulas for color compensation.

The porcelain materials are impervious to dye solution. Any evidences of dye penetration into the facings were due to mechanical defects such as hairline checks and porosities in poorly glazed surfaces. No penetration of dye at the interface area could be noted if there were no mechanical defects at the margins of the gold and porcelain union.

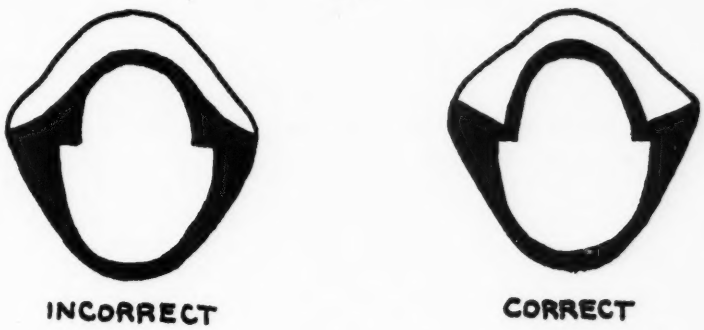
Standardization of the porcelain powders was a problem. New batches varied from the old, both as to fusing temperatures and shading. This necessitated changes in fusing technique and shade formulas.

The design of the gold casting at the interface area is important for good retention of the fused facing. The porcelain should not be fused to a perfectly flat

metal face. A certain design of the metal aids in retention of the facing from a mechanical aspect (Figs. 1 and 2).

The union between metal A and porcelain I creates a strong bond, but a by-product which dissolves into the porcelain is formed at the interface area. This is probably an oxide. The discoloration can be an esthetic problem. However, various

Fig. 1



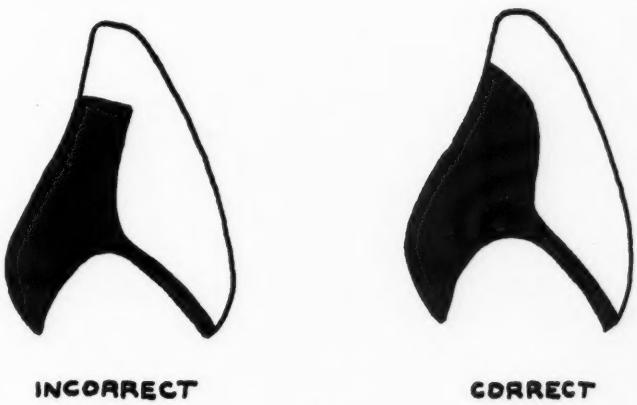


Fig. 2

Fig. 1.—The incisal view of the correct and incorrect design of the gold casting for good retention of the fused porcelain.

Fig. 2.—The mesiodistal view of the correct and incorrect design of the gold casting for good retention of the fused porcelain.

techniques have been utilized to overcome this problem. Porcelain must butt to gold, especially at exposed surfaces. Any slight overlap of porcelain over gold will show the green color. This problem is not present with porcelain III in combination with metals C-1 and C-2.

Porcelain I fired to metal A is strong enough to be clasped by a removable partial denture. It can be used as an abutment tooth, especially when perfect color match with approximating teeth is not crucial.

CONCLUSIONS

Although fused porcelain on gold alloy is a much-needed restoration in the general practice of dentistry, present porcelain-gold systems are not the ultimate and need further investigation and development. All available systems possess certain inherent disadvantages. The metals which produce the best appearance are limited in use because they have Brinell hardness numbers which are low. These metals are easily contaminated, and casting compensation is difficult. Also, higher temperatures are required for fabricating the castings.

The metal possessing the most suitable qualities for dental uses, such as ease of manipulation, physical properties, and fit, gave inadequate esthetic results with its corresponding porcelain. The porcelain proved to be the hardest, and the bond between the two was the greatest.

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A COMBINATION GOLD AND PORCELAIN CROWN

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THE FABRICATION of an esthetic gold and porcelain veneer crown is an important factor whether it be a single unit, a fixed partial denture unit, or a complete mouth rehabilitation. The inadequacy of acrylic resin has been revealed, and the need for a more permanent material is evident. Thus, we have seen the introduction of porcelain bonded to gold and platinum alloys, ranging from a very low fusing temperature type of porcelain to the medium fusing range. One of the chief problems with these materials and procedures is color.

The ability to design and construct a gold and porcelain veneer of proved stability and esthetics is one of our most necessary assets. The technique to be described can be employed for many patients and can be performed by a comparative novice at porcelain work.

TECHNIQUE

A shoulder preparation is made on the labial surface for anterior teeth, as for a full porcelain veneer crown. The lingual aspect of the preparation is chamfered. Thus, the porcelain joins the shoulder without the display of gold. A deeper labial chamfer and a gold collar are used for bicuspids and molars.

The basic concept is that of a half porcelain jacket or veneer crown (Figs. 1 and 2). An elastic impression material and a stone, copper, or amalgam die may be used.

The lingual portion of the crown is waxed to contour and contact. The labial border of the wax is extended so no gold will show on the mesial or distal surfaces (Fig. 3).

The die is removed from the cast and the wax on the mesial and distal surfaces is cut back as far lingually as possible without developing undercuts (Figs. 4 and 5). A hydrocolloid impression is made of the entire labial surface, the shoulder, and the mesial and distal borders of the wax that has been cut back (Fig. 6). A stone cast is poured into this impression and trimmed to permit the adaptation of a platinum matrix. Any slight undercuts can be filled with a cold-cure resin (Fig. 7). A large piece of platinum foil is adapted over the face of the die. The borders of the foil are folded over and crimped to add stability to the platinum matrix (Fig. 8). A piece of rubber dam is wrapped around the matrix and tied with floss, and the matrix is then swaged on the die.

Read before the American Academy of Crown and Bridge Prosthodontics, Chicago, Ill.

The next step is vital to anterior restorations. The labial surface of the matrix must be covered with an opaque porcelain body to within 1.0 mm. of all borders regardless of what type of porcelain is used or its fusing range. A small portion (about ¼ portion) of powdered silex or potter's flint is added to the mixture in order to make the layer sufficiently opaque (Fig. 9).

After the opaque porcelain has been fired enough to set or bind it, porcelain for the first baking is added and scored from the labial gingival to the incisal edge with a sharp instrument to compensate for shrinkage. The porcelain for the second baking is added and fired to the proper vitrification point. The labial surface is ground to the desired contour and given its final glaze.

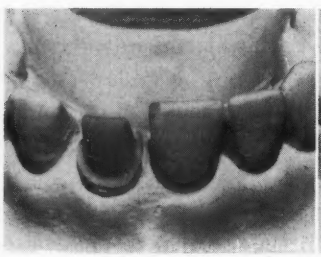

Fig. 1

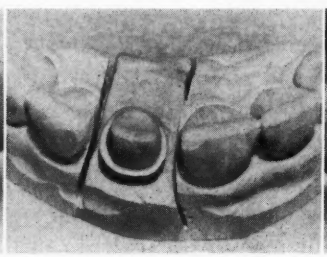

Fig. 2

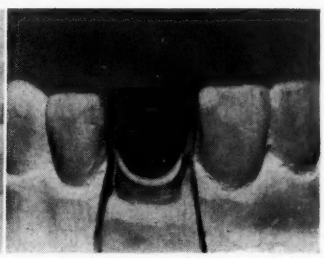

Fig. 3

Fig. 1.—A shoulder preparation is made on the labial gingival surface.

Fig. 2.—The working cast is separated from the adjacent teeth.

Fig. 3.—The wax is carved on the mesial and distal surfaces so that no gold will show in the finished restoration.

Fig. 4

Fig. 5

Fig. 6

Fig. 4.—The wax on the proximal surface prior to removal.

Fig. 5.—The wax on the proximal surface is cut back lingually.

Fig. 6.—A hydrocolloid impression is made of the labial surface. A paper clip serves as a handle while the cast is poured.

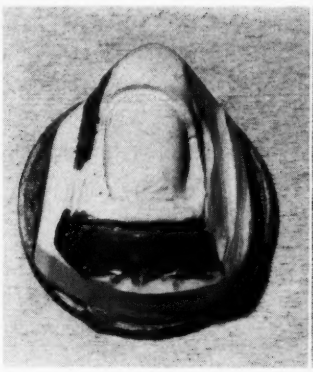

Fig. 7

Fig. 8

Fig. 9

Fig. 7.—Undercuts on the stone cast are filled with cold-cure acrylic resin.
Fig. 8.—A platinum matrix is formed over the stone cast. The folded edges add stability while the porcelain is fired.
Fig. 9.—An opaque material is added before the porcelain is applied.

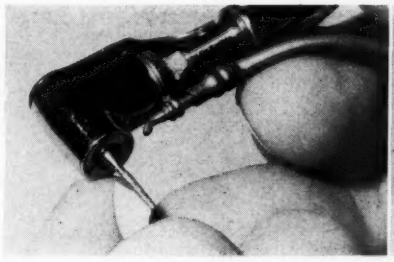

Fig. 10

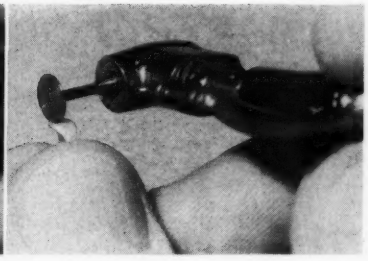

Fig. 11

Fig. 10.—The mesiodistal recess is cut with diamond stones and a water spray.
Fig. 11.—A fine-edge diamond stone is used for the final shaping and contour of the mesial and distal borders.

The platinum matrix is removed, and the small spines of porcelain around the cavosurface angles of the gingival or incisal surfaces are removed carefully with a rubber abrasive wheel or a rotary instrument (Fig. 10).

The porcelain section (facing) is tried on the wax crown. The mesial and distal wings of the facing are prepared on the porcelain sections so as to minimize the display of gold (Fig. 11). High-speed instrumentation is a great advantage in cutting porcelain, especially when the retention wings of the facing are somewhat narrow. Small, tapered diamond stones that are somewhat smooth or worn are excellent for this purpose.

The wings or retentive sections of the facing are polished smoothly with the abrasive wheel after sufficient grinding has been done (Fig. 12). The porcelain section is placed back on the wax pattern, lubricated thoroughly, and held firmly against the labial shoulder while wax is added over the mesial and distal wings of the facing. The wax pattern is sprued and the labial porcelain facing is removed with a small piece of sticky wax. The wax pattern is invested and cast (Fig. 13).

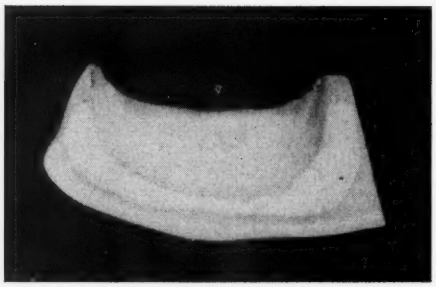

Fig. 12.—The finished porcelain facing shows the mesial and distal reductions.

Fig. 13

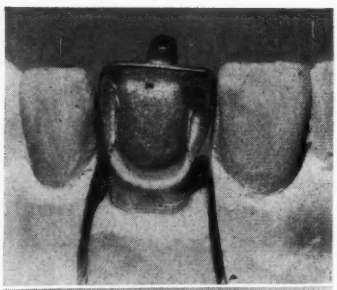

Fig. 14

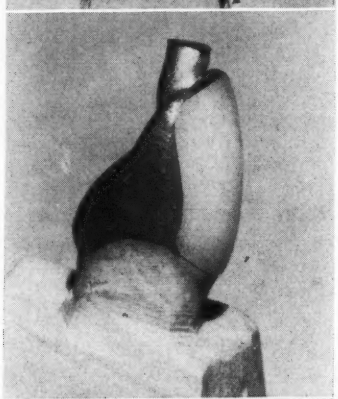

Fig. 15

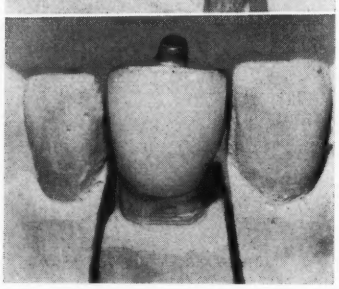

Fig. 13.—The small hole at the incisal part of the finished casting permits the escape of cement during cementation of the restoration.

Fig. 14.—The casting is etched or stripped before the finished facing is forced into place.

Fig. 15.—The finished restoration. When the mesial and distal surfaces are polished for correct contact, no gold will show.

The casting is cleaned and pickled thoroughly before the porcelain insert is tried on it. In most instances, a slight etching with aqua regia or stripping is advisable (Fig. 14). The gold casting is polished and a small vent is cut in it so the casting can be completely seated upon cementation. The porcelain facing is carefully cemented in position. There will be no color change or distortion (Fig. 15).

SUMMARY

Numerous techniques may be used to make a porcelain-faced crown. A stock facing may be ground, platinum pins may be used, or slides for retention or a small box form may be cut in the wax. However, none of these procedures offers ease, final adaptation, and retention without critical steps. The one critical step in the technique described is the stage when the porcelain section is tried on the casting.

Another important feature of the method is that a repair can be made with accuracy. A rubber-base impression is made and a cast of refractory investment material (ethyl silicate and quartz), into which porcelain may be baked and finished, is poured.

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PROCESSING ACRYLIC RESIN VENEERS USING SECTIONAL CORES

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THIS ARTICLE SUGGESTS a simple, accurate, and economical method of constructing acrylic resin veneers. These veneers embody the anatomic details which provide the proper esthetic and physiologic characteristics of teeth.

For the resin veneer to be esthetic, the method must permit ease of trial packing so that the shading and density of the acrylic resin can be controlled. Labial or buccal carvings must be present to break up light reflection. The glazed-finished surface of the veneer which is cured against cellophane should not have to be adjusted or polished.

The physiologic requirement of the veneer is a labial or buccal surface of proper contour to protect, yet allow stimulation of, the underlying tissue (Fig. 1). This contour is accomplished most easily in the wax-up, and the veneer is then cured in such a manner that no grinding is necessary on most of its surface.

PROBLEM OF TRIAL PACKING

This problem normally occurs when veneers are cured on fixed partial dentures of six or more units. When the restoration is invested, undercuts are present on the interproximal surfaces furthest from the center of the restoration (Fig. 2). Previously the laboratory procedures were completed by one of two methods. In one method a "triple flask" was used. This flask is an expensive item and is not practical for the office where few fixed partial dentures are made. The second method involved investing, packing, and curing first one segment of the restoration, then deflasking, waxing, reflasking, packing, and curing the next segment. This is not a good method because of the time involved, the possibility of producing two different shades of acrylic resin, and, most important, the likelihood of tearing the margins or warping the alignment of the castings during all of the flasking and deflasking procedures.

In the technique to be described, the undercuts are overcome by core segments which are not removed vertically with the top half of the flask. The cores are removed in a lateral direction, after the top half of the flask is removed, to avoid tearing or distortion of the resin during the trial packing procedure. The cores also prevent fracture of cured veneers when the flask is opened and during deflasking (Fig. 3).

---

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TECHNIQUE

The assembled fixed partial denture is gold plated to prevent oxidation of gold under the resin which would cause a change of color of the veneers. The labial contours, horizontal and vertical carvings to deflect light, and the embrasures are waxed in detail.

The assembled fixed partial denture with the veneers waxed is invested in the bottom half of a denture flask. The plaster is carried up to, but not over, the waxed veneers. The restoration must be well supported by plaster to resist the vertical forces of packing, and thereby prevent warpage. Undercuts involving either gold or plaster must be avoided just as in flasking a complete or removable partial denture. Prior to investing, a mixture of plaster and pumice is placed inside the crowns to within 1.0 mm. of the margins for easy removal and to reduce the chance of scarring their margins.

A notch or index is made in the plaster in the lower half of the flask to guide the core into the proper location while packing. Separating medium is applied over all plaster.

A heavy mix of artificial stone is poured over the wax on *one-half* of the restoration and into one of the notches to form a core over half of the veneers. After the stone has hardened, all undercuts viewed from above are removed and separating medium is applied (Fig. 4). With the first core in place, a second core is made over the remainder of the fixed partial denture, the undercuts are removed, and separating medium is applied. With the two cores in place, the remainder of the top half of the flask is filled with plaster.

When the flask is opened, if the cores remain in the top half, they are removed with an instrument. If the cores should still be covering the waxed veneers, the cores are gently removed and the wax is boiled out. Any fragile plaster is removed so it will not become incorporated into the resin. A masking agent is applied.

The acrylic resin is mixed and trial packed in the dough stage in the following manner: (1) Mix sufficient gingival or dentine shade and allow the mixture to set. (2) Just before the gingival shade reaches the proper packing consistency, mix the incisal shade. (3) Pack the gingival shade in excess into all necessary areas. (4) Place cellophane over the resin and replace the cores, using the notches to guide them to the proper positions. (5) Replace the top half of the flask and close the flask in a press.

Gently remove the top of the flask. The cores will remain in place covering the veneers. Then the cores are removed in a buccal direction. The success of the entire procedure is based on the fact that the cores are removed in a buccal direction rather than in a vertical direction, which would distort or tear the uncured acrylic resin because of the undercuts in the interproximal embrasures of the posterior teeth. The excess acrylic resin is removed and additional wet resin is added to any unfilled parts for the second trial pack. The exposed acrylic resin is kept wet with monomer during trial packing to prevent crusting.

When the gingival shade of resin is sufficiently dense and partially set, a portion of the middle and incisal acrylic resin is removed. A small amount of the incisal

shade of resin is placed in this space, and the restoration is again trial packed. It is better to underpack than to overpack at this stage so as not to displace the gingival shade.

The flask is opened, the cores are removed, and the shading and density of the resin are observed and adjusted where necessary. Stains may be added for more detailed, esthetic appearance. The cellophane is replaced and the flask is closed.

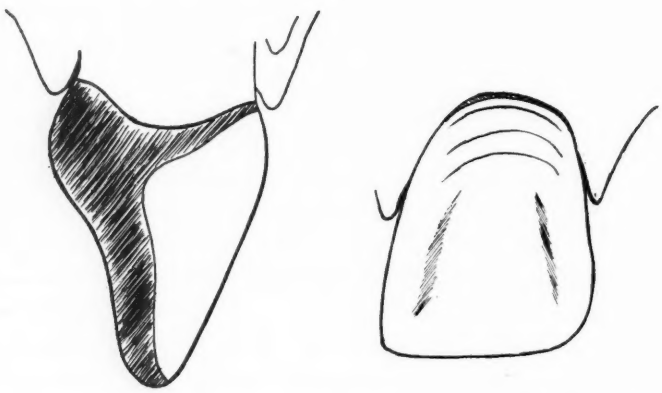

Fig. 1.—Proper contours of tooth surfaces are essential to protect the adjacent soft tissues. The proximal view shows the wrap-around effect of the acrylic resin and the important, fine gold margin which is placed under the tissue and provides a good seal all around the crown. The labial view shows the carvings which deflect light.

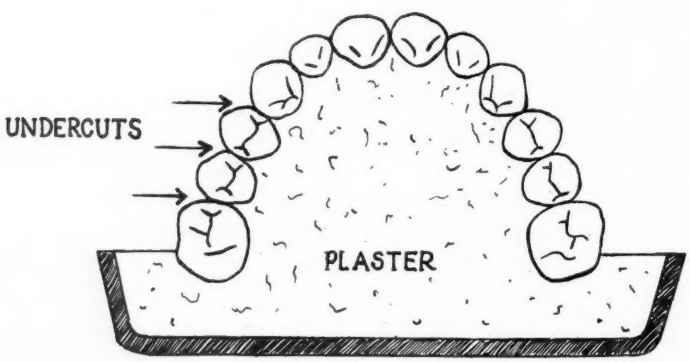

Fig. 2.—A normally invested restoration presents undercuts to a single pour of plaster in the top half of a flask.

After curing, the flask is opened and the cores are removed. The restoration may be heat treated to produce a harder, more resistant acrylic resin.[1] The resin will be highly glazed and possess the proper anatomic form and contours. The shade should be ideal because of the ease of trial packing.

SUMMARY

A simple, inexpensive method of processing full-arch splints or complicated long-span fixed partial dentures with veneers has been described. The artificial stone cores used in the flasking procedure make trial packing possible without distorting the acrylic resin of the veneers.

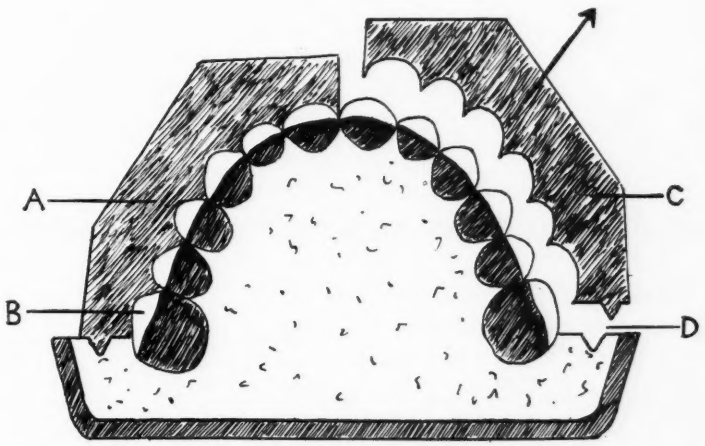

Fig. 3.—A twelve-unit fixed partial denture is invested in the bottom half of a flask. *A*, The stone core is in place over the waxed veneers. *B*, The waxed veneers of the crown castings or pontics. *C*, The sectional core is partly removed; the arrow shows the direction of removal. *D*, The notch or index that guides the core into place. With both cores in place, plaster is poured to fill the top half of the flask.

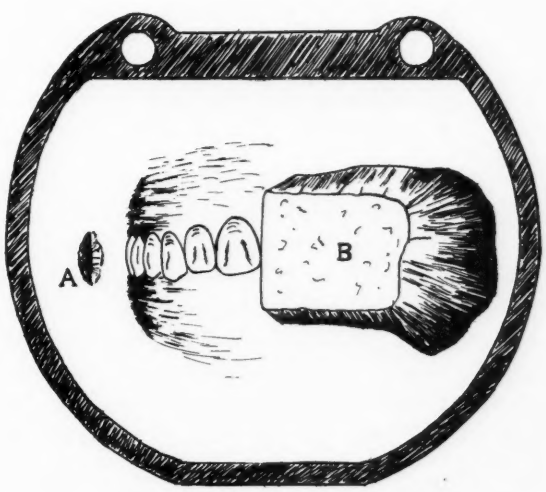

Fig. 4.—The top view shows the restoration invested in the bottom part of the flask. *A*, The notch that guides the core to its seat. *B*, The first stone core has been poured and tapered toward the plaster "land" in the bottom part of the flask to remove undercuts.

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INVESTING AND SOLDERING BROKEN PARTIAL DENTURES

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Complaster* (plaster of Paris and cornstarch) makes a useful matrix in which to hold a broken lingual or palatal bar for soldering.

After assembling the parts in their proper positions, place the assembly gently into a mound of Complaster so that the area to be soldered is left uncovered. Trim the Complaster so the denture will be held in the desired position.

Place the assembly in enough water to cover the Complaster during the soldering. The water will help keep the partial denture cool and lessen the chance of overheating the teeth or resin base. The Complaster will turn brown if it becomes overheated, and thus will give a perfect index as to the amount of heat being absorbed by it.

The Complaster is much more easily removed than plaster after the soldering is complete.

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MODIFIED CAVITY PREPARATION FOR CLASS II AMALGAM RESTORATIONS

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ALTHOUGH AMALGAM is considered an excellent material for restorative purposes, failures with it often occur in dental practice. These failures may be due to fracture, expansion, or corrosion of the restoration or to recurrence of decay.

A study by Roper[1] revealed that approximately 60 per cent of the failures of dental amalgam restorations are due to faulty cavity preparation, whereas 40 per cent could be traced to improper manipulation of the alloy. The technique to be described deals exclusively with cavity preparation.

Four factors of Class II cavity preparations have a direct bearing upon the success of an amalgam restoration. They are: (1) the preparation must be extended so that recurrence of decay can be reduced or prevented; (2) the outline of the cavity preparation must provide sufficient bulk in the amalgam restoration; (3) the preparation must provide mechanical retention for the restoration, since amalgam does not form a physical or chemical union with tooth structure; and (4) the preparation should not undermine enamel rods.

MODIFIED PREPARATION TECHNIQUE

A mesioocclusal preparation of a lower molar with decay on the mesial surface is presented. Ultra-speed (above 100,000 r.p.m.) rotating instruments are used for cutting the tooth structure.

The initial cut is made into the mesial pit of the occlusal surface with a No. 34 or 35 carbide bur. The preparation is extended toward the distal marginal ridge and along all deep fissures for the prevention of recurrent decay. The cut is carried mesially to the position of the axial wall (Fig. 1). The pulpal surface should be flat, seated in dentine, and slightly below the dentinoenamel junction. In general, the width of the occlusal preparation should be one-third of the distance between the buccal and lingual cusps (Figs. 1 and 5).

The enamel rods flare from the dentine to the outer surface in the cuspal region, but they converge more and more as they approach the developmental grooves.[2] If the cavosurface angle formed by the buccal and lingual walls of the

occlusal preparation is less than 90 degrees (Fig. 2), the amalgam will not have sufficient bulk and it may fracture under masticatory stress. If the cavosurface angle is much greater than 90 degrees, unsupported enamel rods remain which may break off (Fig. 3). Therefore, it is best to form a cavosurface angle as close to 90 degrees as possible (Fig. 4). This angle not only prevents the fracture of the amalgam or the enamel, but makes the pulpal portion of the cavity wider than the occlusal part and adds to the retention of the restoration (Fig. 5).

A slight occlusal divergence is created on the distal side where the marginal ridge remains intact. A serious undercut in this region might undermine the entire marginal ridge.[3]

Schour[4] has shown that the enamel rods near the occlusal surfaces of molars and bicuspids are straight for a longer or shorter distance from the surface, but as the dentinoenamel junction is approached, they become twisted. A cut in the

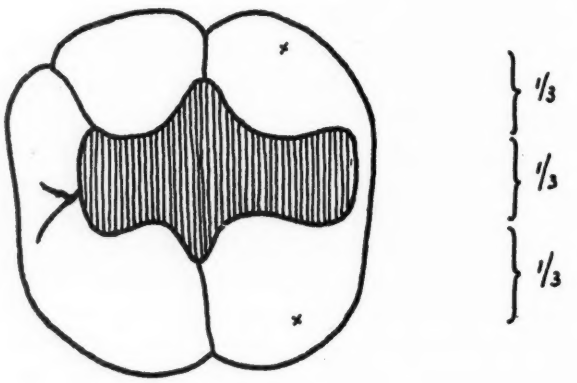

Fig. 1.—The occlusal portion of the cavity is extended along the deep grooves. The width of the cavity buccolingually is one-third of the distance between the mesiobuccal and mesiolingual cusps.

enamel, parallel with the direction of the rods at this surface, may still leave the rods unsupported because they are twisted or gnarled near the dentinoenamel junction. If the initial cut with the carbide bur is followed by the use of chisels or hatchets, the danger of leaving unsupported enamel rods is avoided.

The inverted-cone bur is now used to cut gingivally just inside of the proximal surface of the tooth (Fig. 6). By preserving the proximal wall, the rapidly revolving bur is prevented from damaging the surface of the neighboring tooth. The thin wall of tooth structure which remains can be removed with a hatchet.

The preparation is extended buccally and lingually at the mesial surface with a No. 557 or 558 straight-fissure carbide bur. The handpiece is held at an angle so that the gingival portion of the cavity becomes wider than the occlusal portion.

The question arises as to how far a cavity should be extended in the buccal or lingual direction on the proximal surface. Simon[5] suggests that the extension is

sufficient if the tine of a No. 5 explorer will pass freely between the margins of the preparation and the adjacent tooth as the explorer is drawn along the buccal and lingual walls. If decay has spread along the buccal or lingual walls, the extension of the preparation is governed by the amount of the decay.

Recent investigations[6] have shown that amalgam should not be condensed against sharp angles in the preparation. Sharp angles cause internal stress in the

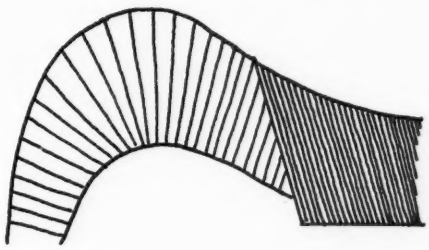

Fig. 2

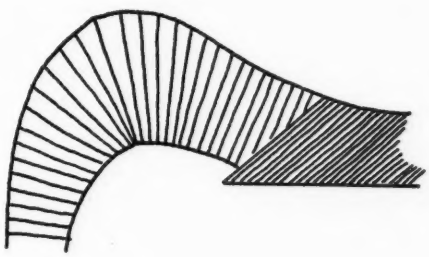

Fig. 3

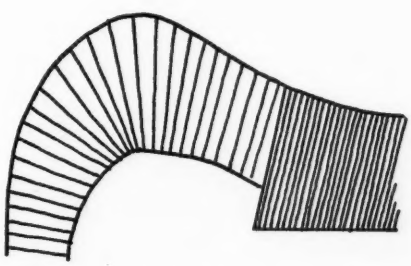

Fig. 4

Fig. 2.—A thin amalgam margin is formed by a cavosurface angle of less than 90 degrees.
Fig. 3.—A cavosurface angle of more than 90 degrees leaves unsupported enamel rods.
Fig. 4.—The cavosurface angle is 90 degrees.

filling material and thus reduce its strength. Therefore, the gingivobuccal and gingivolingual line angle should be rounded to allow better condensation of the amalgam (Fig. 5).

The gingival floor should be placed approximately 1.0 mm. below the margin of the free gingivae. It is cut at a right angle to the occlusal stress. The enamel rods in the gingival portion incline 12 to 15 degrees apically from horizontal. In

order to avoid leaving unsupported enamel rods, the enamel of the gingival seat should be beveled with hand instruments. This is not necessary when the gingival margin is on cementum.

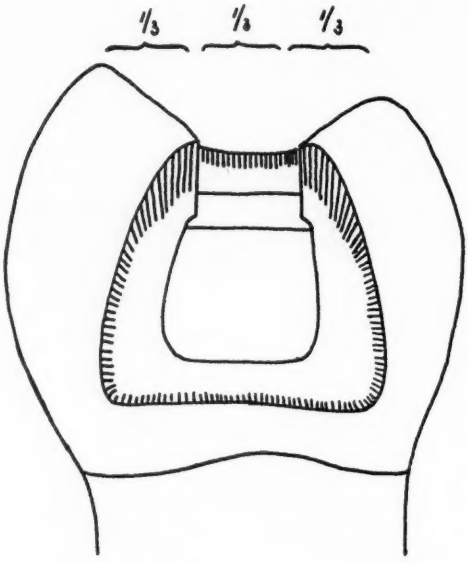

Fig. 5.—Proximal view. The gingivobuccal and gingivolingual line angles are rounded.

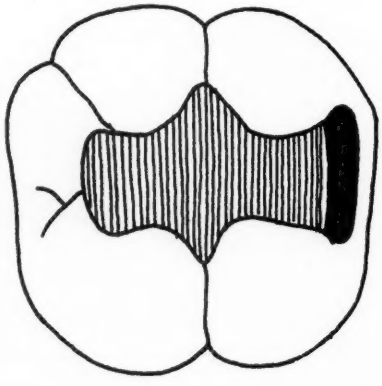

Fig. 6.—The preparation is enlarged toward the mesial margin and then extended into the proximal portion without removing the mesial wall.

The buccal and lingual walls of the proximal preparation should meet the outer surface at an angle as near to 90 degrees as possible (Fig. 7). If this angle is less than 90 degrees, the marginal amalgam will be too thin and may fracture

under stress. For this reason, abrasive paper disks should not be used to establish the buccal and lingual extensions of the proximal preparation.

The axial wall should follow the outer contour of the tooth (Fig. 7). If the axial wall is straight or flat, too much of the dentine may be cut off, thus causing possible harm to the underlying pulp tissue (Fig. 8).

It is difficult to establish smooth walls with an ultra-speed rotating instrument. Therefore, aluminum oxide stones are used in a low-speed, contra-angle handpiece to eliminate the irregularities in the cavity preparation.

Amalgam requires mechanical devices for its retention. Retentive grooves are established along the pulpal and axial walls by means of a No. ½ round bur (Fig. 5). If a cement base is used, a No. 1 round bur is used to produce the retentive grooves.

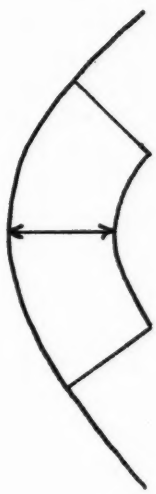

Fig. 7

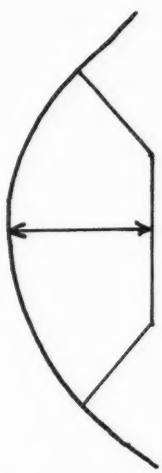

Fig. 8

Fig. 7.—The axial wall follows the outer contour of the tooth.
Fig. 8.—The preparation is deep if the axial wall is cut straight.

CONCLUSION

The cavity preparation plays an important part in the successful insertion of an amalgam restoration. Unfortunately, the filling may not reveal a weakness immediately following its placement. Recurrence of decay, breaking of undermined enamel rods, or fracture of thin amalgam margins may not occur until the tooth has been under masticatory stress for some time. The technique described reduces the possibility of such eventualities.

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NUTRITIONAL CONTROL OF DENTAL DISEASE

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IT IS PERTINENT that Emile Magitot, W. D. Miller, and G. V. Black, the chief proponents of the chemoparasitic theory of dental caries, engaged in the private practice of dentistry. Each had the opportunity of daily observing the natural history of tooth decay in their patients, and all of them had backgrounds in the fundamental biologic sciences equal to those of the most outstanding researchers of their time.

It is unfortunate that scientific knowledge and instrumentation did not develop to the extent that their hypotheses could be adequately tested until the last decade. In the intervening period, many individuals with good intentions, including a surprising number of persons trained only in the basic sciences, have given support to more systemically oriented theories of caries causation.

RECENT FINDINGS

Several recent investigations, however, have provided conclusive support for the Magitot-Miller-Black hypothesis. It is probably not coincidental that the majority of these findings have been made by individuals with hybrid clinical dental–basic science training. Included in this category are the following observations:

(1) *Dental caries does not occur in germ-free animals.* Orland and his associates[1] have shown that rats reared under germ-free conditions do not develop dental caries even when fed high carbohydrate diets. Comparable animals maintained under septic conditions develop excessive tooth decay (Table I).

TABLE I. DENTAL CARIES IN NORMAL RATS AND GERM-FREE RATS INOCULATED WITH KNOWN BACTERIAL CELLS (ENTEROCOCCI PREDOMINATING)

GROUP	MICROBIAL STATE	NUMBER OF RATS	NUMBER OF RATS DEVELOPING MOLAR CARIES
A	Germ-free	9	0
B	Inoculated with enterococci plus others	13	13

(2) *Dental caries does not occur in animals fed carbohydrate diets by stomach tube.* Kite, Shaw, and Sognnaes[2] have demonstrated that rats do not develop dental

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TABLE II. CARIES IN RATS FED A DECAY-PRODUCING DIET VIA NORMAL AND STOMACH-TUBE ROUTES

GROUP	METHOD OF FEEDING	NUMBER OF RATS	AVERAGE NUMBER OF CARIOUS MOLARS	AVERAGE NUMBER OF CARIOUS LESIONS
A	Normal	13	5.0	6.7
B	Stomach tube	13	0	0

decay when they are fed high carbohydrate diets throughout their entire life span by stomach tube. Comparable animals with normal access to the diet, by mouth, had a substantial number of carious lesions (Table II).

(3) *Carbohydrates are retained in the oral cavity for extended periods after food ingestion.* Several laboratories[3] have demonstrated that substantial quantities of carbohydrates may be detected in the mouth for periods up to several hours after mealtime. The concentration of carbohydrates, calculated as glucose, often exceeds 500 mg. per cent and is adequate to support microbial acid production (Fig. 1).

(4) *The microorganisms of the tooth surface metabolize retained carbohydrates with great rapidity.* Stephan[4] has shown that within 2 minutes after a carbohydrate rinse, the pH of tooth-surface plaques of caries-active people may fall below

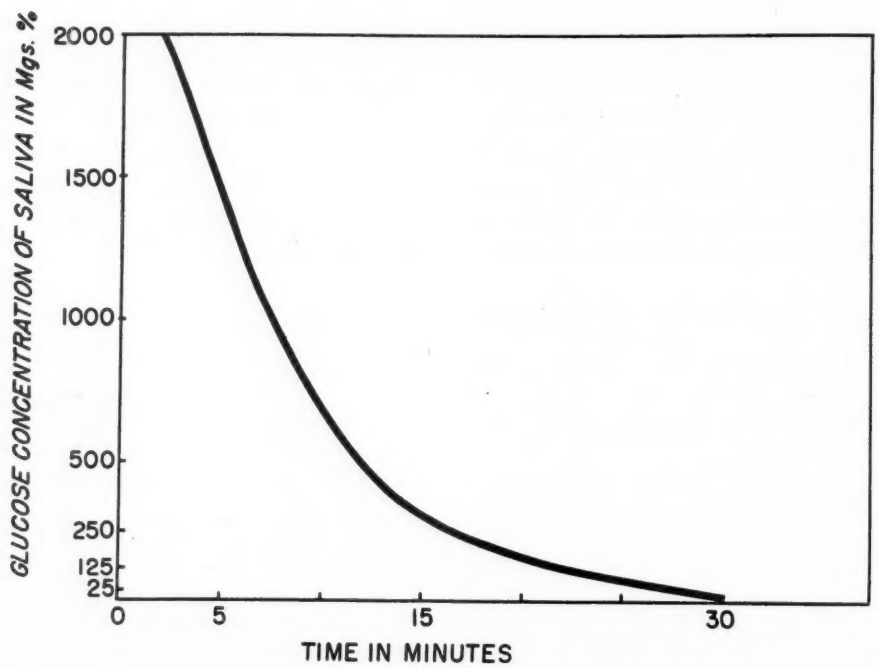

Fig. 1.—The clearance of glucose from the mouth following ingestion of a chewy candy. Carbohydrates may be detected in the mouth in substantial quantities after eating.

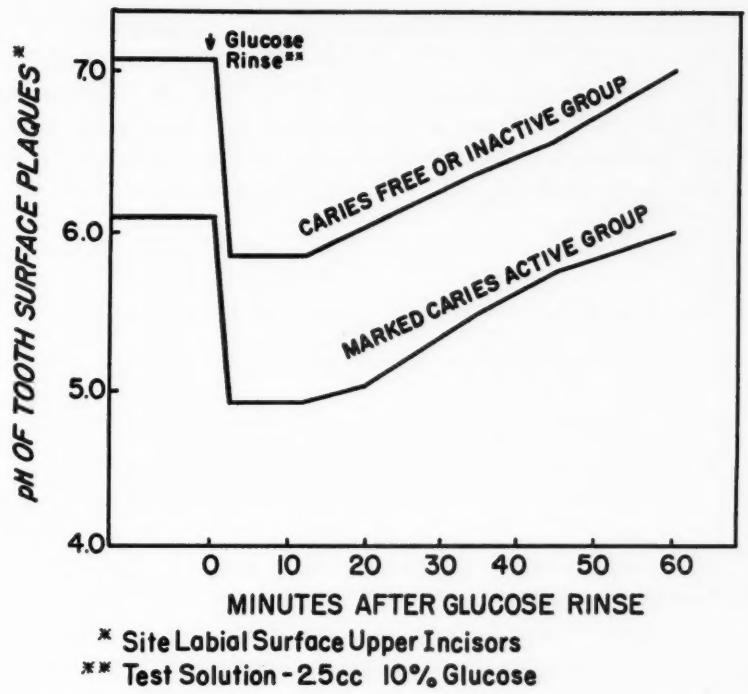

Fig. 2.—Intraoral acid production. A carbohydrate rinse causes the pH of tooth-surface plaques to drop markedly.

5.0. Of further significance is his observation that these tooth-surface acids persist for substantial time periods (Fig. 2).

(5) *The physical nature, not the quantity, of the carbohydrate is the major factor in determining oral retention.* This phenomenon has been extensively investigated in our laboratories.[3] We have fed 500-mg. units of glucose in a cake, lozenge, solution, and gum base, and have observed the variations in pattern seen in Table III.

TABLE III. GLUCOSE IN SALIVA (IN MILLIGRAMS PER CENT) AT INTERVALS AFTER USING 500 MG. OF GLUCOSE

HOW USED	MINUTES				
	0	2	9	16	30
Eaten (cake)	18	1,425	68	20	14
Sucked (wafer)	18	3,304	1,860	1,125	229*
Rinsed (solution)	21	832	105	25	17
Chewed (gum base)	23	725	204	144	27

*Three of the 6 subjects had not completely dissolved their wafer. The 30-minute average figure for dissolving the wafer was 91 mg. per cent.

(6) *The dental caries susceptibility of humans is influenced by the physical nature of dietary sugars.* Gustafsson and his associates[5] have conducted classic clinical research using hospital patients. They have shown that when a diet is supplemented with more than 100 pounds of sugar per year in solution form, there is relatively little increase in the caries attack rate. When a comparable amount of sugar is added in the form of daily toffee rations, rampant dental caries results (Table IV).

TABLE IV. INFLUENCE OF ADDED DIETARY SUGAR OF DIFFERENT PHYSICAL FORMS ON DENTAL CARIES

GROUPS	NUMBER OF SUBJECTS	TOOTH SURFACES BECOMING CARIOUS PER PERSON PER YEAR
Control diet	60	0.30
Control diet + sugar in solution*	57	0.67
Control diet + sugar as toffee (24 pieces per day)	48	4.02

*Amount of added sugar consumed in the two experimental groups was comparable (over 100 lbs. per year per person).

(7) *The comparative retentive characteristics of carbohydrate-containing foods have been established.* Lundqvist[6] and Bibby[7] have determined, in clinical subjects, the quantities of carbohydrates retained in the oral cavity before and at stated intervals after the ingestion of various test substances (Tables V and VI). Although these investigations were carried out independently on separate continents, they are in surprisingly good agreement. They should be utilized by dentists for intelligent dietary evaluation.

(8) *The cariogenicity of carbohydrates is modified by the presence in the diet of other foodstuff components.* When foods of experimental diets containing carbohydrates are heat treated, their caries-producing abilities are potentiated. Evidence indicates that this is associated with modification of the protein fraction of the diet.[8] The presence of fat in the diet tends to inhibit dental caries (Fig. 3).[9] The mechanism of fat action is not known, but it is presumed to be a local one. It is known that fats may alter the surface properties of enamel, inhibit the metabolism of oral microorganisms, and diminish the solubility of dietary sucrose.

More recently it has been reported that certain naturally occurring flavoring agents interfere with acid formation by oral microorganisms. This has been offered as an explanation for a rather low caries attack rate observed in a group of patients who ingested large quantities of sugar in the form of chocolate candy. In support of this concept, it is known that when naringenin, a cocoa bean alkaloid, is added to sugar-containing diets, dental decay in experimental animals is substantially limited.[12]

TABLE V. CARIES POTENTIALITY INDICES OF REPRESENTATIVE FOODS

FOOD	TOTAL SUGAR (%)	SUGAR CONCENTRATION IN SALIVA		CARIES POTENTIALITY INDEX
		MAXIMUM (%)	AVERAGE CLEARANCE TIME (MIN.) ABOVE 0.2%	
Caramel	64.0	18.8	5.0	27
Honey + bread + butter	19.0	4.6	7.5	24
Chocolate, light	47.5	10.1	6.25	21
Honey	72.8	5.6	5.0	18
Sweet cookies (biscuits)	9.0	1.9	5.0	18
Danish pastry	30.0	2.4	2.5	13
Wheaten bread	12.3	2.8	4.0	13
Ice cream	2.4	3.2	2.5	9
Marmalade	65.3	3.5	3.5	10
Marmalade + bread + butter	16.3	1.8	2.5	9
Potatoes (boiled)	0.8	1.6	2.0	7
Potatoes (fried)	3.9	0.4	2.5	7
White bread + butter	1.5	0.8	2.0	7
Coarse rye bread + butter	2.3	1.3	2.0	7
Milk	3.8	0.6	2.0	6
Apple	7.5	0.4	1.0	5
Orange	6.5	0.3	1.0	3
Fruit juice	11.5	1.2	1.0	3
Lemonade	9.3	0.5	0.75	2
Carrot (boiled)	2.4	0.1	——	1

TABLE VI. FOOD RETENTION AND RECALCIFICATION POTENTIALS OF REPRESENTATIVE FOODS

FOOD	TOTAL CARBOHYDRATE (%)	FREE SUGAR (%)	FOOD RETAINED (MG.)	4-HOUR ACID FORMATION ML. 0.1 NORMAL SODIUM HYDROXIDE	DECALCIFICATION POTENTIAL
Cookie (fig)	70.0	27.6	678	1.2	814
Date	77.5	33.8	507	1.6	811
Chocolate	50.0	39.0	370	2.1	777
Ice cream	17.0	——	423	1.6	677
Cookie (shortbread)	59.5	24.8	370	1.3	481
Danish pastry	53.8	40.0	181	1.6	434
Cracker (salted)	70.0	11.0	340	1.2	408
Caramel	56.8	43.0	219	1.8	394
Chocolate pudding	35.0	18.5	300	1.3	390
Cracker (oil sprayed)	71.0	12.1	310	1.2	372
Toffee	90.0	——	266	1.3	346
White bread	49.0	13.0	188	1.8	338
Potato (boiled)	18.2	4.0	128	2.4	307
Cola drink	10.5	10.5	237	1.0	237
Apple	17.5	11.0	228	1.0	228
Orange soda	10.5	10.5	219	1.0	219
Orange juice (fresh)	8.5	——	177	1.2	212
Potato chips	48.2	12.7	61	1.9	116
Carrot (fresh)	9.5	——	73	1.2	88
Carrot (cooked)	8.3	6.8	2	1.5	3

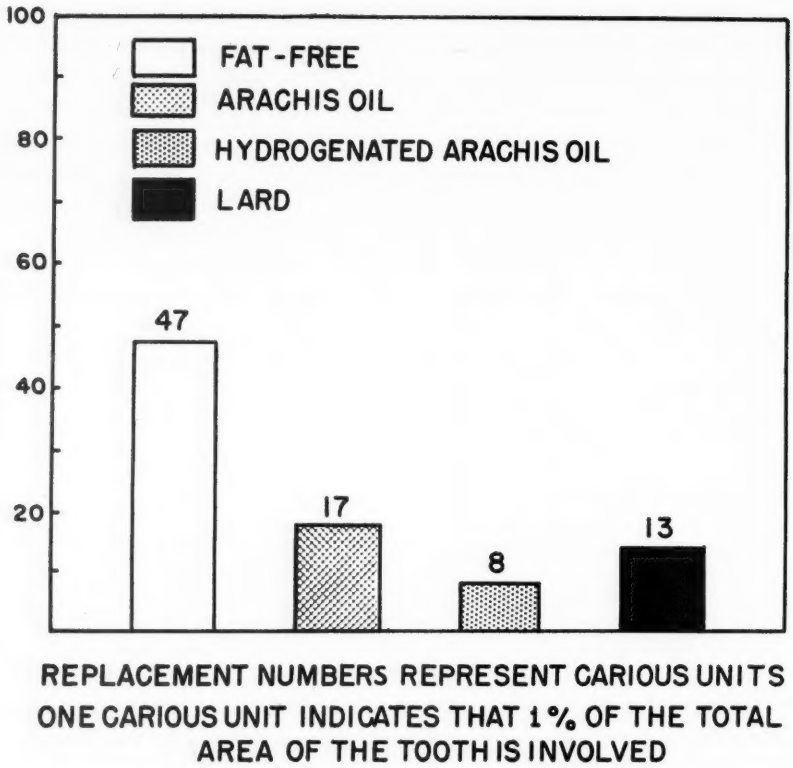

Fig. 3.—The effect of fat on hamster caries. The presence of fat in the diet inhibits dental caries.

(9) *If carbohydrate clearance is accelerated, dental caries is reduced.* It has been shown that tooth brushing in both man and experimental animals[10] substantially reduces the caries attack rate (Table VII).

Unfortunately, the average clinical patient uses an inadequate technique for tooth brushing. There is evidence that a simple mouthwash technique can accom-

TABLE VII. EFFECT OF TOOTH BRUSHING ON HAMSTER CARIES*

GROUP†	REGIME	NUMBER	CARIOUS		
			TEETH	CAVITIES	SCORE
A	Nonbrushing	18	11.2	18.5	35.5
B	Brushing	20	8.2	11.3	17.4

*All figures are averages.

†Animals in each group placed on HWC diet (66 per cent sugar) at tenth day, sacrificed seventy-seventh day.

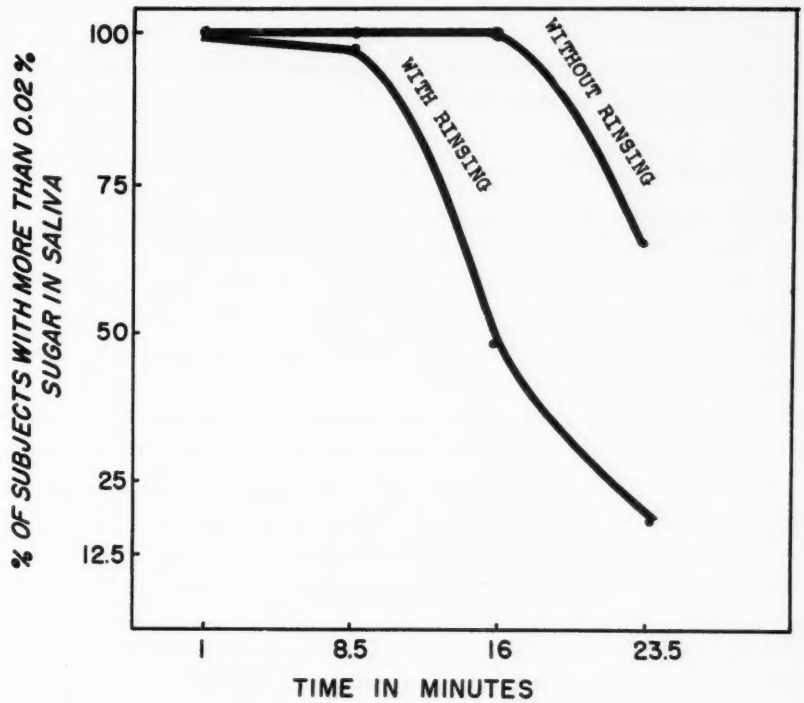

Fig. 4.—The effect of rinsing with 20 c.c. of water on oral sugar clearance. Rinsing with water reduces the oral sugar content.

plish the same results with a minimum of patient effort. Lundqvist[6] has shown that whereas all of a group of patients who did not rinse their mouths after oral sugar saturation were positive for sugar 16 minutes later, 50 per cent of a comparable group who used a single oral rinsing of 20 c.c. of water were sugar free in the same time interval (Fig. 4).

(10) *If carbohydrate clearance is slow, dental caries is accelerated.* It has been repeatedly demonstrated that diminution in salivary flow by ligation or removal of

TABLE VIII. EFFECT OF DESALIVATION ON HAMSTER CARIES*

GROUP†	NUMBER	CARIOUS		
		TEETH	CAVITIES	SCORE
A (Intact salivary glands)	20	2.3	2.5	4.0
B (Desalivated‡)	10	10.5	13.0	39.0

*All figures are averages.

†A—Mature (35+ days old) hamsters, placed on HWC diet (66 per cent sugar) for 100 days. B—Mature hamsters placed on HWC diet (66 per cent sugar) for 79 days.

‡Parotid, submaxillary, and sublingual glands.

the salivary glands in experimental animals greatly accelerates caries production (Table VIII).[10]

Extension of these investigations has indicated that the submaxillary gland is of far greater importance in this regard than the parotid or sublingual gland.

PRESENT PROBLEMS

The foregoing data do much to clarify the general problem of oral carbohydrate retention. The present major concern of the experimentalist is to accumulate information on the specific aspects of carbohydrate retention on those surfaces of the teeth which are particularly prone to dental caries, i.e., the occlusal and interproximal surfaces. MacGregor[11] and our laboratory are among those pursuing this type of investigation.

My co-workers have approached this problem through the construction of removable tooth and denture prostheses. These efforts have included the replacement of full-crown contact areas with human enamel proximal surfaces, substitution of Nesbit-type partial dentures for human teeth, and utilization of partial dentures with removable and interchangeable posterior teeth. The general plan has been to add carbohydrates to these appliances before their insertion into the mouth and to remove them at intervals to ascertain how long the carbohydrates have remained. In certain instances the food has been made radioactive. This permits oral clearance phenomena to be studied with tracer techniques. In other instances the presence of carbohydrates is measured by microchemical methods.

Our findings to date indicate that it is not uncommon for certain carbohydrates to be retained on the occlusal surfaces of teeth for 6 to 8 hours and on the proximal surfaces for 4 to 8 hours. We have also made a preliminary observation that the use of dental floss in the interproximal space prior to carbohydrate addition accelerates clearance from this surface. We are hopeful that other means of limiting carbohydrate retention will result from this research.

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CHANGES IN PULP AND PERIODONTAL TISSUES OF TEETH SUBJECTED TO CROWN PROSTHESIS

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THE PROCEDURES OF CROWN PROSTHESIS involve and affect the anatomic structures of teeth and their supporting tissues. The reaction of enamel to crown preparations is a physical one, since this is a nonvital tissue. According to Schour,[1] "After the enamel is formed and calcified, it can be changed only by the chemical and physical action of its environment, but it has no power of repair or regeneration. Any such thing, therefore, as a vital change in the tissue is biologically unthinkable."

Dentin, however, does have vitality, and it has been assumed that the cutting of dentin such as is necessary for cavity preparation or crown and bridge prosthesis does effect changes in this tissue. These facts are summarized by Schour,[2] who stated, "Bone and dentin matrix are therefore simply calcified intercellular substances containing living cells or living cell processes in the spaces of the matrix which maintain its vitality and nutrition." It is well known that the response of dentin to operative procedures may be the formation of either secondary dentin or sclerotic dentin, or both. Orban[3] describes it thus, "Stimuli of different nature not only induce additional formation of dentin (secondary or irregular), but lead to changes in the dentin itself. Calcium salts may be deposited in or around degenerating odontoblast processes and may obliterate the tubules."

Boyle[4] writes, "Every drilling or grinding of a tooth causes the formation of secondary dentin, provided the operation involves the dentin." He also points out that primary dentin "may respond to injury or exposure of the dentinal tubules by becoming sclerotic."

The tooth pulp, of which the dentin is an integral part, is also susceptible to irritation by mechanical stimuli[5-16] such as cutting for crown preparations. Work done by investigators using animal and human teeth indicates that disruption of the predentin and odontoblastic layers may occur upon cutting the dentin, because of the protoplasmic extensions of the odontoblasts within its dentinal tubules. Actual pulp changes, such as hyperemia, have also been observed. Partial and total pulpitis have been attributed to irritation from invasion of dentin by cutting of

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this tissue. Pulp abscesses and complete necrosis of the tissue have been noted as sequelae to the cutting of the dentin.

Crown and fixed partial prostheses are also related to the periodontal membrane and the alveolar bone because of the effects of changes in stress they impose upon these tissues. Stresses on the periodontal membrane and alveolar bone have been investigated mostly from the points of view of orthodontics[17-24] and periodontics.[25-33] Flourens, in 1847, was the first to state that, in tooth movement, resorption took place on the side of the bone toward which pressure had been exerted,

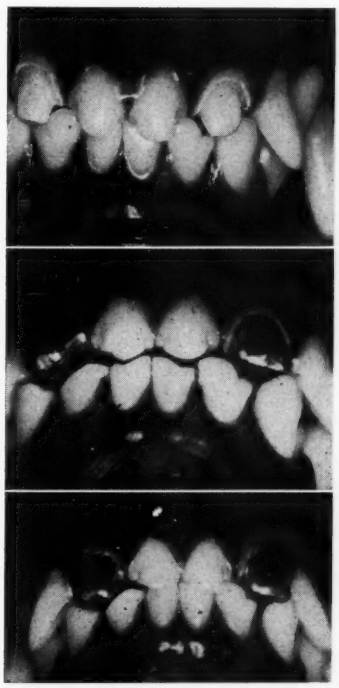


Fig. 1.—Dog 3. The crown preparations with the teeth in occlusion after cementation and 1 week later just prior to sacrificing the animal.

with deposition of new bone on the opposite side. Sandstedt[23] proved Flourens' theory by means of experimental studies in the dog. He showed areas of hyalinization and concomitant marginal bone resorption at the pressure side of the periodontal membrane. The recent work of Macapanpan[24] confirmed this observation. Workers in the field of periodontics have also observed these changes in the supporting structures after placing restorations high in occlusion in experimental animals. Agreement does not exist, however, as to whether such restorations produce a "traumatic occlusion" which causes periodontitis. In 1939 Orban[30] concluded that "traumatic occlusion produces pathology in the peridental membrane." In 1955, Bhaskar and Orban[33] came to the conclusion that "occlusal trauma, contrary to

various claims, does not produce gingivitis, periodontitis, pockets, pulp stones, recession, festoons, clefts, erosion or caries."

It is evident that operations upon the teeth are related to histologic changes in the tooth itself and the supporting tissues, such as the free gingiva and marginal and radicular periodontium. These microscopic changes, however, have not been sufficiently investigated from the standpoint of crown and fixed partial prosthesis.

METHODS AND MATERIALS

This study of the effect of crown prosthesis is divided into two phases: (1) histologic changes which occur in the periodontium and (2) those found solely within the dental pulp. The study of stresses applied to the periodontal membrane and the adjacent bone by crown preparations was accomplished with specimens from three

TABLE I

TOOTH	PREPARATION	METHOD	TIME ELAPSED (DAYS)
U.L.1	J.C.*	Turbojet	85
U.R.3	J.C.	Turbojet	78
U.R.1	J.C.	Cavitron	82
U.L.3	J.C.	Cavitron	71
U.R.2	J.C.	Chayes-Page	78
L.L.2	J.C.	Chayes-Page	19
L.R.3	F.V.C.†	15,000 r.p.m.	31
L.R.4	F.V.C.	15,000 r.p.m.	31
L.L.3	F.V.C.	Air turbine	19

*Shoulder jacket-type crown preparation.

†Full-shoulder crown preparation with much wider buccal or labial surface reduction to make space for a veneer window.

young dogs. The effect of the crown preparations upon the tooth pulp was observed in the same dog specimens and, in addition, in teeth of two human beings.

The first dog had full-crown preparations with gingival shoulders performed on the maxillary third incisors. Diamond stones at 6,000 r.p.m. were used under drops of water. The teeth were left without covering for a period of 1 week, at the end of which the animal was sacrificed and the premaxilla distal to and including the third incisors was removed.

Dog 2 had full-crown shoulder preparations performed on the maxillary second incisors, using the same operative procedures as in dog 1. In this case, impressions, casts, and wax patterns were made, and the finished crowns were cemented within 3 hours of the operative procedures. The left crown was designed slightly high in occlusion, and the right crown was taken completely out of occlusion by grinding the opposing mandibular incisors. Two weeks after this operation, the animal was sacrificed and the premaxilla was sectioned. The prepared teeth of this second dog are not illustrated, but are similar to those of dog 3 shown in Fig. 1.

A third dog received the same operative and prosthetic treatment as dog 2, except that the crown on the maxillary right second incisor was placed much higher in occlusion than in the preceding case. Another difference consisted in time elapsed between cementing the crowns and sacrificing of the animal. In this case, the interval was 1 instead of 2 weeks. Fig. 1 shows, respectively, preparation of the dog's teeth, the crowns in centric occlusion right after cementation, and the crowns in occlusion just before sacrificing the animal.

The second phase of the study, that is, the effect of crown preparation instrumentation on the dental pulp, was accomplished by using teeth from two human subjects as well as the cut teeth of the three dogs mentioned above.

TABLE II

TOOTH	PREPARATION	METHOD	TIME ELAPSED (DAYS)
U.L.1	J.C.*	Cavitron	16
U.R.1	J.C.	Turbojet	11
U.R.3	J.C.	Turbojet	7
L.R.2	J.C.	Chayes-Page	9
L.L.2	J.C.	Chayes-Page	9
L.L.3	J.C.	Chayes-Page	9
U.L.3	J.C.	Air-turbine	8
L.R.3	F.V.C.†	Chayes-Page	9
L.R.4	F.V.C.	Chayes-Page	9
L.R.5	F.V.C.	Chayes-Page	9
L.L.4	F.V.C.	Chayes-Page	9
L.L.5	F.V.C.	Chayes-Page	9
U.R.4	F.V.C.	Turbojet	7
U.R.5	F.V.C.	Turbojet	7
U.L.4	P.V.C.‡	Air-turbine	8
U.L.5	P.V.C.	Air-turbine	8

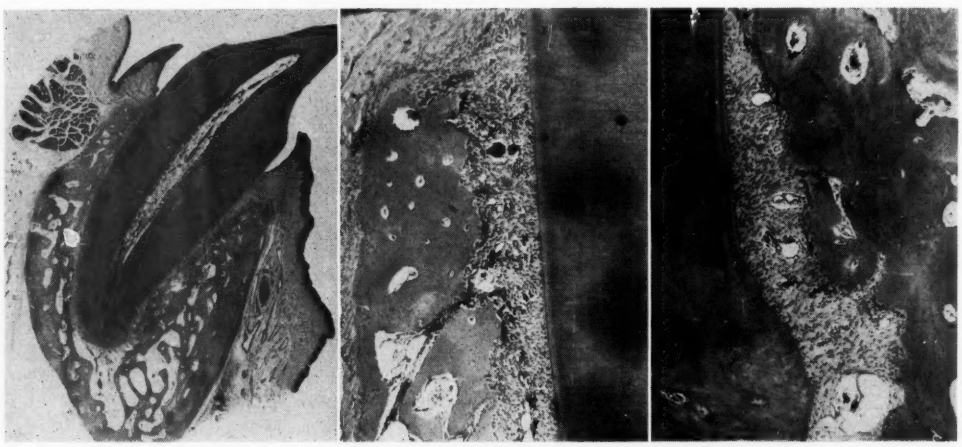
*Shoulder jacket-type crown preparation.
†Full-shoulder crown preparation with much wider buccal or labial surface reduction to make space for a veneer window.
‡Partial veneer crown with proximal boxes.

The first patient, a white woman, aged 35, who was about to undergo extraction of her remaining nine noncarious and unfilled teeth for complete denture prosthesis, was chosen because the roentgenograms showed that the pulps of the teeth were relatively large. Crown preparations were performed under local anesthesia (Table I). The time elapsed between the operation and the extraction is given. The nine cut teeth were covered with temporary crowns, using a zinc oxide and eugenol anodyne cement. During the preparation of the maxillary left central incisor of this first patient, the pulp was exposed in the mesial surface, near the incisal angle. There was no bleeding or pain, and the pinkish area of exposure was barely visible.

Following extraction, the nine teeth of this first patient were roentgenographed in two directions: (1) buccal or labial and (2) proximal. Besides being a help in determining possible pulp exposures, these roentgenograms of every specimen

helped in the orientation of the tooth for trimming after decalcification and prior to embedding them in paraffin. The roentgenographic view of the pulp made it possible to decide, for each tooth, whether a mesiodistal or labiolingual histologic section would show the pulp cut surface relations to the best advantage. In addition to the roentgenographic method, the cut teeth were examined under the dissecting microscope to determine any possible pulp exposures. During these examinations the specimens were not allowed to dry. Each tooth was then cut transversely, just below the anatomic crown, so that the pulp tissue could be more completely fixed and embedded in paraffin. Histologic sections were prepared and stained with hematoxylin-eosin.

The second subject was a white woman, aged 40, with sixteen unfilled teeth with large, healthy pulps. The patient was to undergo extraction of all the teeth because of periodontoclasia. Table II shows the treatment for the teeth of this patient. All procedures were similar to those followed with patient 1.



A. *B.* *C.*

Fig. 2.—Dog 2. *A*, The maxillary second incisor at low magnification. *B*, The labial alveolar crest at higher magnification. *C*, The linguoapical regions at higher magnification.

HISTOLOGIC FINDINGS

The histologic sections from both teeth of dog 1 show that the teeth had erupted during the experimental period. The histologic picture is similar to that of dog 3 (see Fig. 3). These teeth exhibited no increase in mobility during the experimental period.

The pulps of the cut teeth of this first dog showed an even and undisturbed predentin and odontoblastic layer. The blood vessels were filled with red cells.

The histologic section of the maxillary left second incisor of dog 2 which had a crown placed in occlusion is illustrated in Fig. 2. The labial-marginal gingiva attachment is undisturbed and very thin, with little or no epithelial hyperplasia.

The subepithelial cellular infiltration is consistent with normal. The palatal free gingiva shows some thickening and cellular infiltration consistent with normal.

The labial-marginal third of the alveolar bone shows many areas of osteoclastic activity on its periodontal membrane side. On its vestibular side there is new bone apposition. The fibers of the lingual-marginal periodontal membrane are stretched and the membrane is wider near the crest of the alveolar bone than at any other

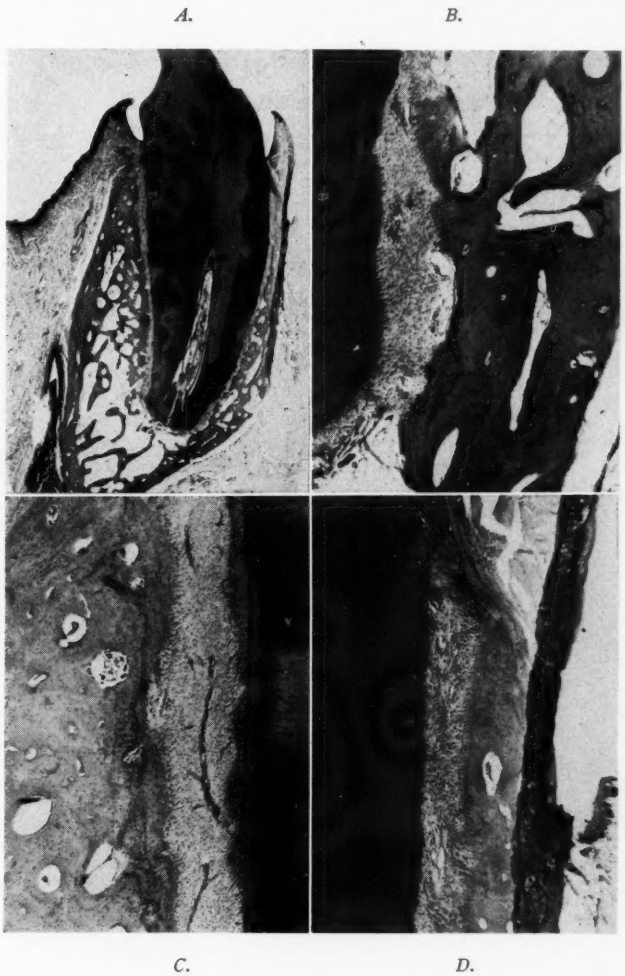


Fig. 3.—Dog 3. *A*, The maxillary right second incisor. *B*, The linguoapical regions *C*, The lingual crest. *D*, The labial crest in greater detail.

part. In the linguoapical region the bone margin shows baylike areas, probably areas of recent bone resorption. There are no osteoclasts visible and, in fact, there is evidence of osteoblastic activity. The picture is consistent with a recent labial rotation of the tooth along an axis somewhere in the middle of the root. This tooth exhibited an increase in mobility at the beginning of the experimental period, but was again firm in its socket when the animal was sacrificed.

The pulp shows many large blood vessels filled with red blood cells and is otherwise normal in appearance.

The other histologic section from dog 2 is the maxillary right second incisor. This tooth was covered with a gold crown which was placed out of occlusion. The gingiva and the pulp are within normal limits. The periodontal membrane and alveolar bone show the same histologic picture as in the next tooth, which will be described in detail.

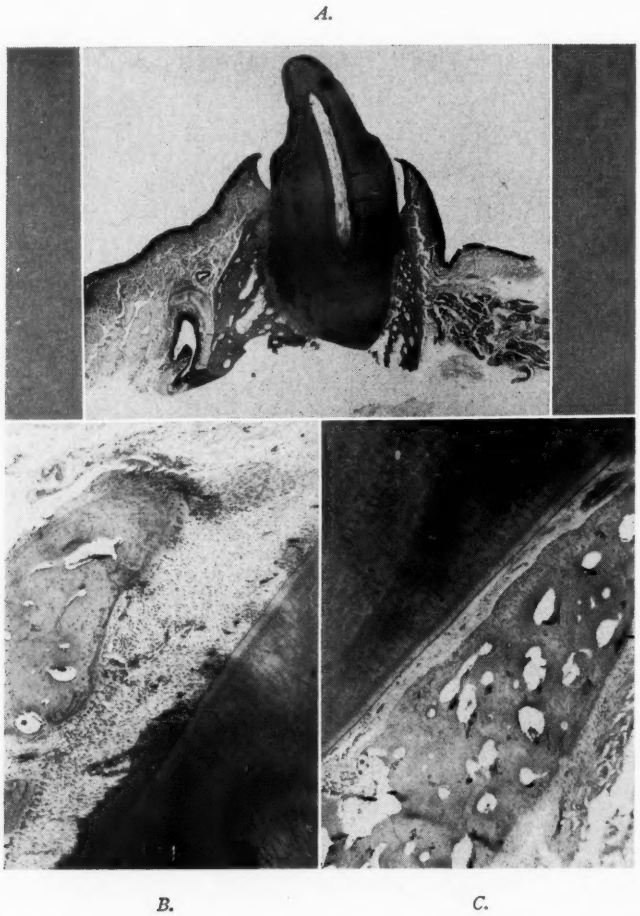


Fig. 4.—Dog 3. *A*, The maxillary left second incisor. *B*, The lingual crest. *C*, The labial periodontal membrane near the crest.

The maxillary right second incisor of dog 3 was covered with a gold crown and placed out of occlusion. Fig. 3 shows the histologic section of this tooth. Both gingivae are within normal limits, and their attachment is found at the cemento-enamel junction. All along the margin of the alveolar bone there is apposition of bundle bone. There is also marked apposition of bone on each alveolar crest. The explanation for this new bone growth is that the whole tooth has erupted during the experimental period. The general direction of all the periodontal membrane

fibers is oblique and they are directed incisally from the bone to the cementum. The pulp tissue shows no signs of trauma. In this case the interval between operation and recovery of the tissues was 1 week. No increase in tooth mobility was observed in the experimental period.

The other histologic section from dog 3 is that of the maxillary left second incisor, which is illustrated in Fig. 4. This tooth crown was placed high in occlusion. The labial side is the pressure side and shows a hyalinized area of the periodontal membrane. This hyalinization consists of loss of practically all cell structure, with disorientation of the principal fibers. The hyalinized area starts abruptly at the tip of the bony septum and includes over one-half of the labial periodontal membrane. At the apical end of this area of hyalinized periodontal membrane, there is connective tissue activity in the bone. One can see hyperplasia of the adjacent medullary connective tissue with irregular osteoclastic enlargement of the bone spaces. This is undermining resorption of the bone. The cementum is not affected; neither is there any evidence as yet of organization of the hyalinized periodontal membrane.

On the tension side the periodontal membrane has been widened more than five times its original width, and bone is being deposited in the periodontal membrane side of the alveolar bone. Both marginal gingivae are clinically normal, although they show the usual histologic picture of low-grade chronic inflammation. The tooth mobility increased at the beginning of the experimental period, but when the animal was sacrificed the tooth was again firm in its socket. The pulp shows no signs of trauma.

The histologic section of the first human tooth is that of a maxillary left central incisor. The mesial pulp horn of this tooth was exposed while preparing the mesioincisal angle (Fig. 5). Coagulated pulp tissue covers the exposed mesial pulp horn. Some remnants of blood vessels and erythrocytes are observed within the coagulated mass, but the true architecture of the tissue has, for the most part, been lost. Adjacent to this degenerated tissue there is considerable leukocytosis and proliferation of the pulp tissue with blood vessels engorged with blood. The vessels show enlarged endothelial cells and diapedesis can be observed. The remaining major portion of the pulp is normal in appearance and not hyperemic. However, there are some areas of vacuolization. The vacuoles have about them a pseudomembrane caused by peripheral compression of the tissue. Although some of these large vacuoles approximate the area of inflammation adjacent to the exposure, they are still considered artefacts. A denticle is visible in the pulp.

The other twenty-four human teeth show no evidence of pulp exposure or of pathologic conditions in the pulp tissue. Many of the histologic sections show artefacts, among which are tears, vacuoles, odontoblasts cut in cross section, and blood vessels full of red blood cells. The thickness of dentin between the pulp and the deepest part of the preparation varied from 0.5 mm. to 1.5 mm.

SUMMARY AND DISCUSSION

In two dogs, maxillary third incisors and maxillary second incisors which were placed out of occlusion erupted in a direction along the long axis. New bone

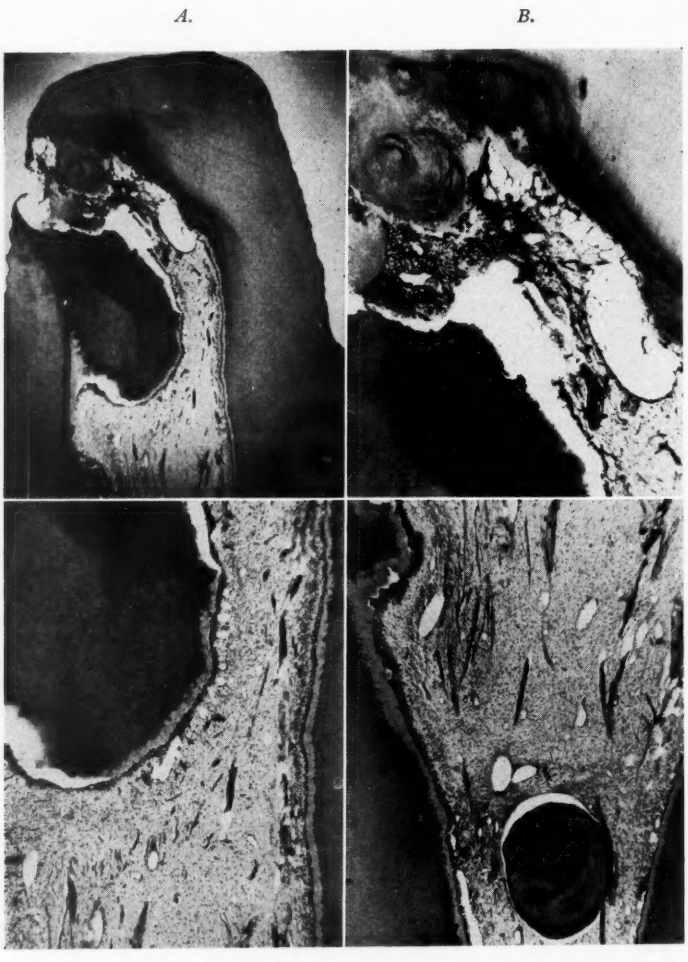


Fig. 5.—Patient 1. The pulp of the maxillary left central incisor. *A*, The exposed area at a low magnification. *B*, A high magnification of the exposed area. *C* and *D*, The more apical portions of the pulp.

apposition was observed at the crest and along the entire wall of the alveolus of these teeth. The general direction of the periodontal membrane fibers was oblique and they were directed incisally from the alveolar bone to the cementum. The teeth did not exhibit an increase in mobility.

In two dogs, two maxillary second incisors which were placed high in occlusion rotated in a labial direction. This rotation was accompanied by bone resorption at the labial-marginal and at the linguoapical alveolar wall. Bone apposition was observed at the vestibular side of the labial alveolar bone. The extreme pressure which was applied to one of these teeth by putting the crown very high in occlusion resulted in hyalinization and reorganization of the periodontal membrane, accompanied by undermining resorption of bone but not cementum. The teeth

exhibited increased mobility during the beginning of the experimental period, but were firm again at the time the animals were sacrificed.

No evidence of permanent injury to the dental pulp was observed in six dog teeth and in twenty-four human teeth which had various types of crown preparations performed on them with slow- and high-speed instrumentation. One human tooth which had the pulp exposed during crown preparation showed signs of acute inflammation when extracted 85 days after the operative procedures. The zinc oxide and eugenol paste which was used under the temporary crown served as palliative in this tooth, but it was not compatible with proper healing.

Throughout the many years that dentists have been constructing artificial tooth crowns, certain clinical observations have been obvious. Among these is the fact that in cases where the new crown changes the stresses upon the supporting structures, the altered teeth finally become stable, useful members of the dental apparatus for years to follow. This research clearly illustrates the histologic changes that take place around teeth which have altered their position as a result of crown prosthesis. These changes do not go beyond the physiologic limits of these supporting tissues, that is, they are nonpathologic changes.

In the cases where the crowned teeth were placed in infraocclusion, one can see that new bone was deposited about the entire alveolus and at the alveolar crest, so that occlusion was re-established with adequate bony support. This contradicts the opinion held by some clinicians and investigators that placing a tooth slightly out of occlusion brings about relative elongation, that is, loss of marginal bony support.

In the cases where the new crowns were designed in supraocclusion, lateral displacement of the tooth occurred. The early stages of this change may be accompanied by injury, that is, destructive hyalinization of the periodontal membrane, but without inflammatory changes.

This research shows that the extensive cutting which is necessary for the removal of the crown enamel and part of the dentin in the preparation of the tooth for an artificial crown does not injure the pulp. This may be because of the fact that while the cutting is extensive and even painful, it is at a safe distance of at least 0.5 mm. from the pulp in adult teeth. Pulp injury occurred only when this tissue was exposed. It should be pointed out that this exposure did not bleed and was very difficult to detect with the naked eye.

The research also showed that, barring the possibility of pulp exposure, handpiece speeds from 6,000 to 200,000 r.p.m., when used in commonly accepted clinical practice, do not cause irreversible changes in the pulp tissue.

CONCLUSIONS

1. Crowns which are cemented high or out of occlusion will produce histologic evidence of resorption followed by apposition of bone in the supporting tissues of the teeth. The tissues re-establish equilibrium and become stable when the teeth attain their new position. In some instances there is histologic evidence of hyalinization of the periodontal membrane on the pressure side; in other instances, connective tissue hyperplasia is evident without tissue destruction.

2. The procedures used in the accepted clinical practice of crown prosthesis, with low- and high-speed instruments, do not cause pathologic reactions in the dental pulp, unless a pulp exposure is produced.

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PERIODONTAL THERAPY BY ROOT RESECTION

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ELIMINATION OF PERIODONTAL POCKETS by means of root resection is an old procedure which was described by G. V. Black.[1] Yet, during the past decade relatively few articles have been published on this method. Only Sorrin[2] and Messinger and Orban[3] have reported on this mode of therapy. The purpose of this article is to report several instances where root resection was the treatment of choice for the elimination of periodontal pockets.

AN INVOLVED MESIAL ROOT OF A MANDIBULAR MOLAR

Severe bone loss and deep periodontal pockets had developed around the mesial root of the mandibular right first molar (Fig. 1, *A*). Periodontal pockets around the distal root and the remaining teeth were amenable to routine periodontal therapy.

Treatment.—Root canal therapy was used on the distal root (Fig. 1, *B*). Then, the tooth was split buccolingually and the involved mesial root was extracted (Fig. 1, *C*). A fixed partial denture was latter made which extended from the right mandibular first bicuspid to the distal root of the first molar. The bicuspids were used as double abutments (Fig. 1, *D*).

AN INVOLVED DISTAL ROOT OF A MANDIBULAR MOLAR

Severe bone loss and deep circumferential pockets had developed around the distal root of the right mandibular first molar (Fig. 2, *A*). There were no teeth posterior to this tooth. Its antagonist, the maxillary right first molar, was to be extracted because of a carious exposure. No restoration was to be placed distal to the mandibular right molar.

Treatment.—Root canal therapy was used on the two mesial roots of the right mandibular first molar. Then, the tooth was split buccolingually and the distal root was extracted. Three-quarter crowns were constructed for both the bicuspid and the mesial half of the mandibular molar. The crowns were soldered together for increased stabilization (Fig. 2, *B*). The appearance of the tooth in the patient's mouth is shown in Fig. 3, *A* and *B*.

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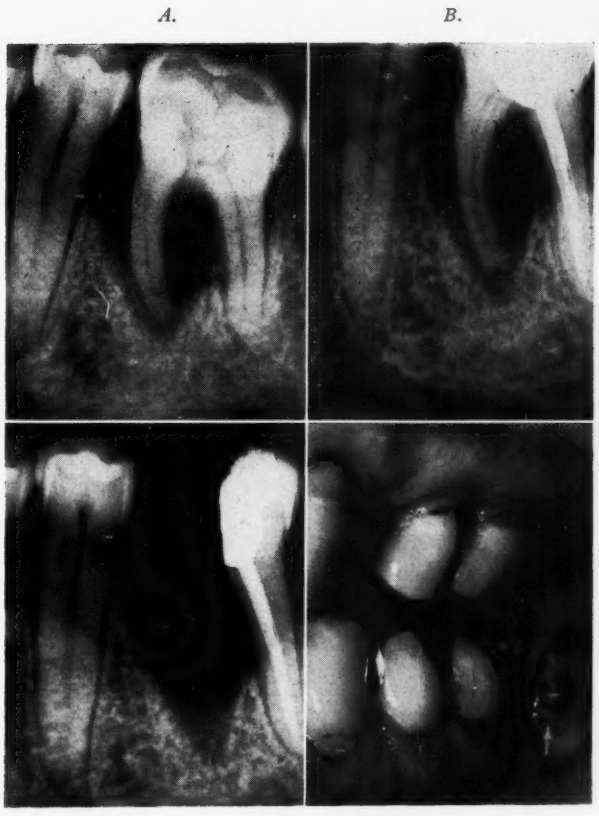
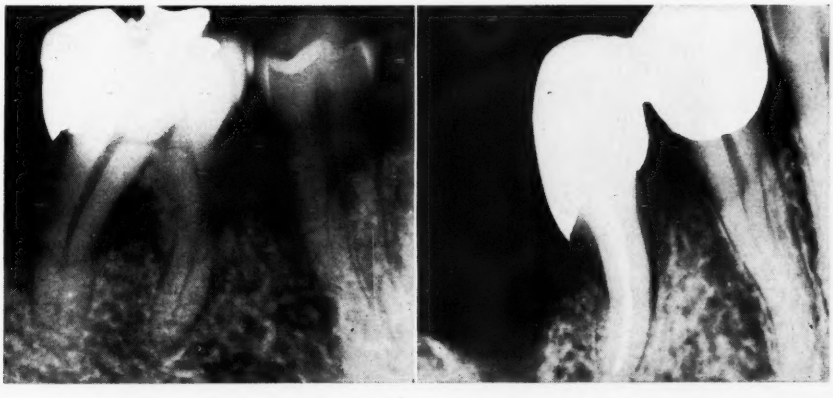


A. *B.*

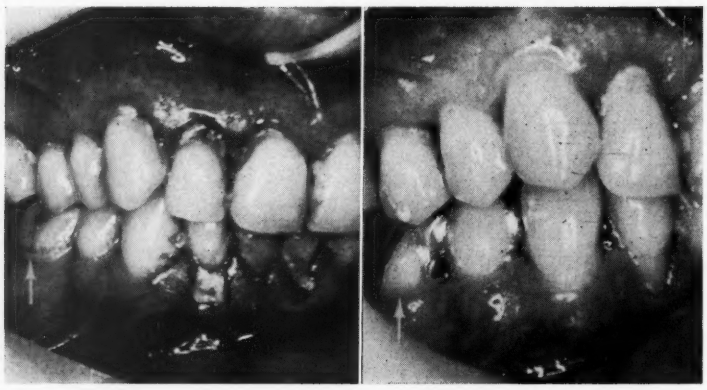
C. *D.*

Fig. 1.—*A*, Note the severe bone loss around the mesial root of the mandibular first molar. *B*, The root canal therapy was done on the distal root only. *C*, The mesial root has been extracted. *D*, A fixed partial denture was constructed from the first bicuspid to the distal root of the first molar (arrow).



A. *B.*

Fig. 2.—*A*, Note the severe bone loss around the distal root of the mandibular first molar. *B*, The root canal filling is in the mesial root of the mandibular first molar. The distal root of the first molar has been extracted.



A. *B.*

Fig. 3.—*A*, The arrow indicates the first molar shown in Fig. 2, *A*. *B*, The restoration is completed. The arrow points to the mesial root of the mandibular first molar shown in both Fig. 2, *B* and Fig. 3, *A*. The patient has a congenitally missing mandibular bicuspid.

A.

B.

Fig. 4.—*A*, The first bicuspid, an abutment tooth in a fixed partial denture, has a hopeless prognosis. *B*, Although the root of the first bicuspid has been extracted, the crown has been left in place.

AN INVOLVED ABUTMENT TOOTH IN A FIXED PARTIAL DENTURE

A fixed partial denture extended from the maxillary right cuspid to the second molar. The cuspid, first bicuspid, second bicuspid, and second molar teeth were abutments (Fig. 4, *A*). Deep periodontal pockets and severe bone loss extended to the apex of the root of the first bicuspid. Thus, the prognosis for this tooth was hopeless.

Treatment.—A vertical incision was made on the labial gingival tissue of the right cuspid. The incision extended from the gingival margin almost to the mucobuccal fold. The flap was loosened with a periosteal elevator and turned upward. Then, the exposed root of the first bicuspid was severed at the cementoenamel junction with a fissure bur and the root was removed.* The crown of the tooth was left in place (Fig. 4, *B*). No pulp chamber was found in this tooth because it had been obliterated with secondary dentine. Had one been present, however, it would have been filled with amalgam alloy. By root resection, the periodontal problem was eliminated and the patient was spared the inconvenience of having the old fixed partial denture removed and a new one constructed.

SUMMARY AND CONCLUSIONS

There are many advantages to eliminating periodontal pockets by means of root resection. In addition to eliminating the periodontal pocket, this procedure retains an abutment tooth. In some patients, this may obviate the construction of a removable partial denture. In other instances, the retained tooth may lend additional support for a removable or fixed prosthesis. In occlusal rehabilitation, the splinting of approximate abutments is recommended to prevent pathologic periodontal conditions such as tooth mobility, distal movement of abutment teeth, and bone resorption. Thus, it follows that the more teeth which can be maintained in a patient's mouth, the better the prognosis.

The three resections described have proved to be satisfactory to the patient, and the teeth have remained in health and function for a year or more.

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TEMPOROMANDIBULAR JOINT DYSFUNCTION

TREATMENT OF TEMPOROMANDIBULAR JOINT DYSFUNCTION

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DYSFUNCTION OF THE TEMPOROMANDIBULAR JOINT is due to abnormal dental occlusions in more than 90 per cent of the cases. The clinical manifestations of this functional disorder are multiple and often involve the entire neuromuscular system.[1-4]

Although the range of symptoms varies with each patient, the neuromuscular symptoms that usually manifest themselves are (1) temporomandibular joint clicking accompanied by crepitation, (2) irregular opening and closing of the mandible, (3) limited or excessive mandibular movement, (4) mandibular subluxation, (5) condylar hypermobility, and (6) a vicious and, frequently, exquisitely painful cycle of muscle spasm—pain—spasm that is often the precipitating factor in the patient's desire for medical assistance.

MUSCLE SPASM

"Muscle spasm is a reversible state of shortening which is no longer under voluntary control, but usually is associated with neural reflex action. Owing to protective splinting, muscles that are affected can cause other muscles or other sections in the same muscle, to go into spasm. In this manner, the effect and the area of the spasm are greatly increased. In the acute stage muscle spasm appears to be a neurophysiologic disorder, but with the passage of time the spasm becomes chronic, and the tissues undergo organic changes. The cycle—muscle spasm, pain, spasm—can be initiated by pathologic occlusion which creates neuromuscular dysfunction. When a patient closes in centric relation and strikes an interfering contact, stimulation of the proprioceptors and pain receptors initiates mandibular movement to avoid the interference. The mandible then assumes an unphysiologic convenience relationship, and the co-ordination of the neuromuscular system is thrown out of balance. The condyles, the rami and the body of the mandible are now in an unphysiologic position. The muscles, the tendons and the ligaments attached to these parts are also in a convenience relationship . . . [which] has

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taken over the placement of the mandible. . . . [Consequently,] the teeth do not permit the muscles to return the mandible to its centric-relation position. However, the normal reflex control of the muscles is constantly attempting to return the mandible to centric relation. This continuous stimulation causes the muscles to remain in a state of sustained contraction without movement. The effect of this un-co-ordinated neuromuscular activity is dysfunction, pain and muscle spasm. The primary hyperactivity of those muscles that are in convenience mandibular relationships is added to secondarily by the hyperactivity of the musculature that retracts the mandible, and thus the un-co-ordinated function results in primary and secondary muscle spasm. . . . The interfering occlusal contact, pathologic occlusion and resulting un-co-ordinated musculature produce primary noxious stimuli that travel to the central nervous system, which in turn produces other areas of muscle spasm."[5]

REFERRED PAIN

Thus, through the mechanism of referred pain, temporomandibular joint dysfunction can be responsible for numerous sites of head pain.[6-10] Head pain, in turn, may radiate into the neck and shoulder regions, along the arms into the fingers, and down the back as far as the lumbar spine.[11,12] The pain is dull and constant, unrelenting in nature, and aggravated by mandibular movement.

Fig. 1 delineates the extent to which the temporomandibular joint acts as a trigger in producing pain in the frontal, temporal, occipital, nuchal, orbital, zygomatic, mental, auricular, and cervical regions. No one patient will have pain in all these areas. They represent the zones of pain, occurring in various combinations, that can be triggered by temporomandibular joint arthrosis.

TREATMENT

Treatment of temporomandibular joint dysfunction calls for concomitant therapy of three major structures: the temporomandibular joint, the musculature, and the teeth. In most instances correction of occlusal disharmony, discussed in another article,[5,13] alleviates all properly diagnosed temporomandibular joint dysfunctions. In the past 9 years, some 558 patients have been treated successfully for temporomandibular joint dysfunction mainly by eliminating the occlusal disharmony. Roughly 80 per cent of the patients were female and 20 per cent male; 60 per cent were between 20 and 40 years of age. Therefore, temporomandibular joint arthrosis as a disease entity is not due to the aging process, as is osteoarthritis. Each patient must be given a thorough clinical examination, and a detailed, pertinent medical and dental history must be acquired.[5,12]

Before corrective dental procedures can be undertaken, the patient is given at least partial symptomatic relief. These patients usually exhibit acute exacerbated pain, which often they have endured for long intervals. Furthermore, in the presence of trismus, limitation of mandibular movement, or subluxation, the necessary correction of the occlusal disharmony is difficult, if not impossible, to perform.

Direct drug therapy of the temporomandibular joint is used for these patients. The two most effective agents for intra-articular injection have been

hyaluronidase and hydrocortisone acetate. They have been used for 347 patients. Adjuvant therapy, in addition to the routine administration of moist heat, analgesics, and vitamins, consisted of muscle relaxants such as meprobamate, ethyl chloride spray, and direct injection of procaine hydrochloride into the muscles.

Hyaluronidase.—Hyaluronidase is indicated in the treatment of functional temporomandibular joint disease because the enzyme lyses viscous hyaluronic acid[14] and promotes synovial fluid absorption.[15,16] Thus, the fluid balance between the joint capsule and the adjacent tissue is restored. Because of the spreading action of hyaluronidase, its use is contraindicated in the presence of bacterial infection.

Fig. 1.—A schematic diagram which illustrates the prevalence of sites of pain referred from the temporomandibular joint. *X*, The trigger area (temporomandibular joint). The shaded areas indicate referred pain (degree of intensity indicated by depth of color).

Hydrocortisone Acetate.—Injections of hydrocortisone acetate are most effective in treating noninfectious, inflammatory conditions of the temporomandibular joint. Strean,[17] Henny,[18] and Costen[19] feel that the steroid also acts specifically to reduce pain and trismus. The intra-articular use of hydrocortisone acetate is contraindicated by the existence of active infection such as tuberculosis or the infectious arthritides.

The capsule of the temporomandibular joint lies about 5 mm. beneath the skin. Delivery of medication within the capsule is necessary for full therapeutic effect. Accurate placement of the needle tip within the synovial cavity is accomplished by the following procedure. After the movement of the condyle within the joint as the patient opens and closes the mouth is noted visually, the forefinger is placed over the preauricular area and pressed inward. The patient opens his jaws widely, and the finger pressure is maintained on the area for a minute or two. Upon removal of the finger, a depression will become evident. The center of the depression locates the site of the injection.

Using a sterile surgical technique, 1.0 c.c. of 2 per cent procaine hydrochloride is placed into the soft tissues surrounding the joint to ensure a painless injection. With the patient's jaw opened widely, 150 to 300 TRU. and 0.5 to 1.0 c.c. (10 to 25 mg.) of sterile hydrocortisone acetate suspension is injected with a 24-gauge needle into the capsule of the joint. The needle is inserted gently into the joint capsule (about 10 mm.) until resistance is met (Fig. 2). This technique deposits hyaluronidase and hydrocortisone acetate into the upper synovial joint space. Injection of the lower joint space is unnecessary because of the spreading action of hyaluronidase. Further injections of hyaluronidase and hydrocortisone acetate may be repeated at weekly intervals to control temporomandibular joint symptoms.

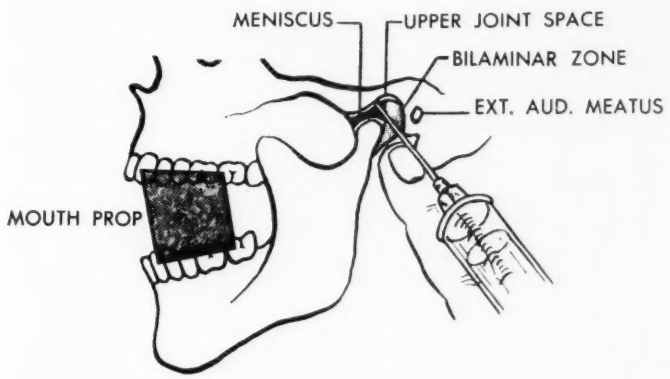

Fig. 2.—Demonstration of the temporomandibular joint injection technique. (From Shore, N. A.: Occlusal Equilibration and Temporomandibular Joint Dysfunction, Philadelphia, 1959, J. B. Lippincott Company).

Meprobamate.—Meprobamate is a normotropic agent with widespread clinical use.[20] It is used to allay anxiety and nervous tension,[21] and it is beneficial in reducing muscle spasm and rigidity.[22]

Meprobamate therapy should be initiated at the first appointment in a dosage of one 400-mg. tablet three times daily. If insomnia or nocturnal bruxism persists, a fourth tablet may be taken at bedtime. The dosage may be increased or decreased to control symptoms of muscle spasm and anxiety. The maximum recommended daily dose is 2,400 mg.

Procaine Hydrochloride.—Infiltration of 0.50 per cent procaine hydrochloride without a vasoconstrictor into the parts of muscle that are in spasm and into trigger zones acts to interrupt the spasm—pain—spasm cycle and provide relief from pain.[23] Procaine in this concentration has produced no toxic effects.[5,23,24]

Ethyl Chloride Spray.—Ethyl chloride spray is accepted by many as an agent capable of reducing muscle spasm. Travell,[25] Kraus,[26] and Shore[5] discuss in detail the pathologic mechanism and rationale for such treatment.

Other Adjuvants.—Heat, vitamin therapy, and analgesics are well-known adjuvants in the treatment of temporomandibular joint dysfunction.[5]

CASE REPORT

A 45-year-old woman had persistent head pain of 10 years' duration. The medical diagnosis was neuritis of undetermined origin. Meperidine hydrochloride had been prescribed by her physician.

On clinical examination, pain areas were found in the frontal, right nasal, vertex, occipital, right zygomatic, right preauricular, and right cervical areas. In

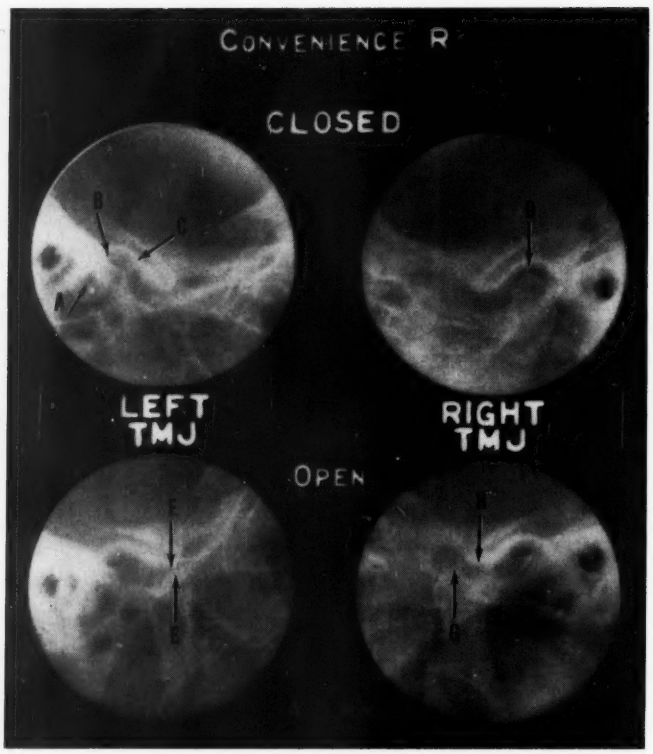

Fig. 3.—Lateral roentgenograms of the right and left temporomandibular joints in the open and closed positions. The left joint gap is wide posteriorly at *A* and is almost nonexistent superiorly at *B* and anteriorly at *C*. Note the equidistant joint gap at *D*. In the open position, the center of the left condyle, *E*, is under the center of the eminence, *F*. The center of the right condyle, *G*, is anterior to the center of the eminence, *H*.

addition, the patient experienced pain in the right shoulder, arm, and fingers. The greatest pain intensity occurred on arising. Speech and mastication caused exacerbation of pain. Upon awakening, the patient frequently felt dizzy and found the jaws clenched. During the day she clenched and ground the teeth involuntarily.

Stethoscopic examination revealed crepitation in the right temporomandibular joint and clicking in both joints. Both joints subluxated. The anterior wall of the left external auditory meatus was tender on palpation. Palpation of the right temporal muscle elicited pain in the anterior fibers and in the area of its insertion on

the coronoid process. Shooting pains were felt in the temporomandibular joint when this muscle was examined. The right and left zygomatic areas were painful on palpation of the masseter muscles, as was the internal pterygoid muscle near the medial surface of the mandibular angles. Palpation of the trapezius muscle evoked pain radiating into the base of the neck and the arms which was more pronounced on the left side.

An interference in centric relation was found between the upper and lower left second molars. The mandible deviated to the left during closing. The maximum opening, as measured between the incisors, was within normal limits about 40 mm.

Fig. 4.—Posteroanterior temporomandibular joint roentgenograms in the closed position of the same patient. The left condyle is in a superior position at *A*. The fixed reference lines, *H* and *J*, are on the skull. The movable reference lines, *K* and *L*, are on the lateral edges of the condyles.

Roentgenograms of the temporomandibular joint (oblique-lateral transcranial projection), closed position, revealed the left joint gap to be wide posteriorly and almost nonexistent superiorly and anteriorly (Fig. 3). The right joint gap was normal. The posteroanterior view (midorbito-meatal base line–corner of mouth projection), closed position (Fig. 4), revealed the left condyle in a superior position and a bodily shift of the mandible to the right, as evidenced by the relationship of the condyles to their respective fossae.

The centric-relation interfering contacts between the upper and lower left second molars were created apparently by the removal of the lower first molar. Tipping of the remaining molars followed. The interference caused the mandible to move into a pathologic protrusive medial relation with respect to the upper jaw. The protrusive shift caused the lower anterior teeth to strike against the lingual surfaces of the upper teeth, which resulted in a thickening of the lamina dura and periodontal spaces around the anterior teeth. The malposition of the mandible produced pain and muscle spasm to the head and neck.

A diagnosis of abnormal mandibular protrusive-medial relationship and temporomandibular joint disease was made. The following plan of treatment was put into effect: (1) injection of procaine hydrochloride, 0.25 per cent in saline solution, into painful areas and spastic muscles, (2) intra-articular injection of hyaluronidase, 150 TRU., into the right joint, (3) intra-articular injection of hydrocortisone acetate, 0.6 c.c. into the right joint, (4) meprobamate, 400 mg. three times daily, (5) vitamin therapy (ascorbic acid, thiamine chloride, and intramuscular injection of B_{12}) to aid in restoration of general body nutrition, and (6) equilibration of the occlusion in centric and eccentric positions.

Within 3 weeks, clicking, crepitation, vertigo, and pain in the temporal, masseter, and pterygoid muscles had disappeared. In the course of several weekly visits, the occlusion was equilibrated in centric and eccentric positions. After 9 weeks of treatment, the pains in the neck, shoulders, and arms were gone. Maximum mandibular opening increased to 46 mm. The mandible no longer deviated to the left in the opening movement. Twelve weeks after the initiation of therapy all joint symptoms and pain areas had vanished. A follow-up, 20 months later, revealed a completely asymptomatic individual.

SUMMARY

Functional temporomandibular joint disease may be caused by occlusal disharmony and produces a characteristically painful syndrome. Meprobamate is recommended for relief of the anxiety state, as well as for the alleviation of the accompanying muscle spasm. The simultaneous intra-articular injection of hyaluronidase and hydrocortisone acetate is most effective in relieving symptoms while corrective dental measures are carried out. The injection technique is described. A typical case history is given.

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IMPRESSION MATERIALS

DETAIL DUPLICATION TEST USED TO EVALUATE ELASTIC IMPRESSION MATERIALS

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INDIRECT IMPRESSION TECHNIQUES, involving various types of materials, are widely used in dental practice. The accuracy of any cast produced by such techniques is primarily a function of the inherent accuracy of the impression material. This accuracy of reproduction is, however, dependent on the dimensional behavior of the materials involved and the surface condition of both the impression and cast. Dimensional accuracy has been studied by numerous methods[1-5] but most have not been concerned with surface detail, per se.

Surface accuracy does involve the duplication of surface details and is dependent on both the interfacial relationship between the impression material and the original object and the compatibility of the impression material and the cast material. This article reports the results of tests on ten impression materials, used in combination with three gypsum-base cast materials, in regard to their ability to reproduce surface details. It is not the purpose of this article to compare individual brands of material within a given group, but rather the behavior of various types of impression materials. Results on individual batches might certainly vary from the data obtained here, especially with the silicone materials which are undergoing radical change.

METHODS

The test models were stainless steel cylinders ½ inch by ⅜ inch. A pattern of Knoop indentations was placed on the polished surface of the die, each pattern consisting of three scales of seven indentations.[6,7] The seven indentations of each scale were of the following average dimensions:

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Indentations	Length (μ)	Depth (μ)
1	422	28
2	307	20
3	202	13
4	109	7
5	62	4
6	43	3
7	34	2

Three such dies were placed in a test block and a mix of each impression material was used to secure impressions of the three test models. The manufacturer's directions were carefully followed and standardized in all phases of proportioning, mixing, gelling, curing time, etc., for the various impression materials. After an impression was made, it was observed under uniform lighting at 16-power magnification and the number of indentations reproduced in the impression material was recorded. Observations were made under optimum optical conditions—placing the impression at an angle to the incident light and the viewing microscope so that the surface of the impression would act as a mirror.

Within 10 minutes after separating the impression of the three test models from the models, a mix of one of three gypsum-base model materials was prepared according to the manufacturer's directions and mechanically vibrated into the impression. The poured impression was stored in an atmosphere of 100 per cent humidity while the stone was setting. The casts were separated from the impressions within 1 hour, plus or minus 15 minutes, after pouring. Using the same previously described method, the number of indentations present on these models was recorded.

The purpose of this study was not only to evaluate the ability of the test method to provide reproducible measurements in the hands of the same investigators, but also to check the results of various operators in handling the same groups of materials. Thus, two separate laboratories ran duplicate tests with the same materials, although not necessarily the same batch numbers (in some of the tables it will be noted that a few additional or different brands have been employed). Hereafter in this report, the results from Columbia University will be referred to as from laboratory No. 1 and those from Indiana University as from laboratory No. 2. As will be pointed out, the data obtained by each group was analyzed somewhat differently. This was done purposely in order to provide some additional observations not possible with only the one set of data.

RESULTS

In Table I can be seen the data obtained by laboratory 1 with the various impression materials. Each material was used to make impressions of eighty-one scales, a total of 567 individual indentations. Any test impression was discarded if it was marred by a gross void or discrepancy. It is recognized that such imperfections may be due to operator error in mixing or inserting the material;

however, the merits of any impression material should be to minimize such discrepancies, even with proper manipulation, and to reproduce accurately the critical areas.

The first column (Table I) indicates the total number of indentations reproduced in the impressions, the second column the per cent duplication of the total number possible, while the average number of indentations duplicated on each scale (the highest possible being 7) is seen in the last column. As a group, the alginates reproduced an average of only 3.1 indentations per scale, the reversible hydrocolloids 6.0, the silicones 6.4, and polysulfide rubbers 6.7.

Comparable results were obtained by laboratory 2, although, due to a slight difference in the way the data were collected, the actual percentages do differ. In this series, more concern was given to the ability of the material to reproduce the

TABLE I. INDENTATIONS REPRODUCED BY VARIOUS IMPRESSION MATERIALS, LABORATORY 1

MATERIAL	TOTAL INDENTATIONS	PER CENT DUPLICATED	AVERAGE NUMBER OF INDENTATIONS PER SCALE
Hydrocolloid			
Deelastic	481	84.7	5.9
Surgident	491	86.6	6.1
Alginate			
Jeltrate	213	37.6	2.6
D.P.	297	52.3	3.7
Polysulfide rubbers			
Permlastic	534	94.1	6.6
Coe-Flex	533	95.9	6.7
Silicone			
Siligel	542	95.9	6.7
Elasticon	506	89.2	6.2
S.I.R. (syringe)	489	86.2	6.0
S.I.R. (tray)	532	93.7	6.6

finer detail rather than the over-all reproduction of the total number. Thus slight discrepancies, such as voids, were disregarded provided the detail was sharp and the succeedingly smaller indentation was invariably present. In order to minimize voids, a syringe was used to inject all materials.

The data is presented in Table II, representing mean values for a total of eighteen impressions with each material. The voids in the table indicate, of course, a 100 per cent reproduction of that indentation by the material. It is again apparent that the polysulfide rubbers, silicones, and hydrocolloids were excellent in their ability to reproduce the smaller indentation, while the alginates were poor.

The measurements on the stone dies poured in the various impressions by laboratory 1 can be seen in Table III. The data show both the average number of indentations present in the original impression and the corresponding reproduction by each of the three stones. All stones invariably failed to reproduce all the in-

TABLE II. INDENTATIONS REPRODUCED, BY SIZE, LABORATORY 2*

MATERIAL	INDENTATION NUMBER†						
	1	2	3	4	5	6	7
Hydrocolloid							
Deelastic							54(100%)
Surgident						52(96%)	43(80%)
Alginate							
Jeltrate			51(94%)	47(87%)	33(61%)	16(30%)	1(2%)
Coe				47(87%)	35(65%)	17(31%)	4(7%)
Polysulfide rubbers							
Permlastic							54(100%)
Coe-Flex							54(100%)
Silicone							
Silgel							54(100%)
Elasticon							52(96%)
Justi							53(98%)

*Below each indentation number is shown the actual number reproduced (54 being the highest number possible for any one size indentation) as well as the percentage of reproduction.
†1 = largest, 7 = smallest indentation.

dentations which were present in the impression materials themselves. This observation has been noted by Fusayama.[8] As a total, the stones reproduced 11 per cent of the alginate indentations, 23 per cent from hydrocolloids, 38 per cent from the polysulfide rubbers, and 34 per cent from the silicones. Calculating the percentage of indentations reproduced by each individual stone to the total number presented by all the impression materials, Vel-Mix reproduced 36.5 per cent, Duroc 25.0 per cent, and Castone 22.0 per cent.

TABLE III. MEASUREMENTS ON STONE DIES, LABORATORY 1*

IMPRESSION MATERIAL	INDENTATIONS PRESENT IN IMPRESSIONS AND DUPLICATED BY STONE		
	VEL-MIX	DUROC	CASTONE
Deelastic	159 — 41	152 — 50	170 — 54
Surgident	161 — 68	159 — 59	171 — 56
Jeltrate	51 — 37	77 — 3	85 — 3
D.P.	100 — 15	117 — 0	86 — 0
Permlastic	176 — 92	176 — 60	180 — 67
Coe-Flex	182 — 62	183 — 61	179 — 69
Silgel	177 — 33†	185 — 0†	180 — 23†
Elasticon	169 — 80	168 — 79	169 — 70
S.I.R. (syringe)	134 — 94	164 — 75	116 — 46‡

*The data show the number of total indentations present in each impression material, followed by the number reproduced in the cast.
†Numerous bubbles.
‡Specimens from one test block (63 indentations) discarded.

TABLE IV. MEASUREMENTS ON STONE DIES, LABORATORY 2*

MATERIAL	INDENTATION NUMBER IN ORDER OF DECREASING SIZE						
	1	2	3	4	5	6	7
Deelastic — Number present	18	18	18	18	18	18	18
Vel-Mix } Number duplicated	18	18	13	2	—	—	—
Duroc } Number duplicated	18	18	14	—	—	—	—
Castone } Number duplicated	18	18	18	6	—	—	—
Surgident — Number present	18	18	18	18	18	17	14
Vel-Mix } Number duplicated	15	10	2	—	—	—	—
Duroc } Number duplicated	18	15	6	—	—	—	—
Castone } Number duplicated	18	16	10	2	—	—	—
Jeltrate — Number present	18	18	16	15	11	5	1
Vel-Mix } Number duplicated	2	—	—	—	—	—	—
Duroc } Number duplicated	2	—	—	—	—	—	—
Castone } Number duplicated	1	—	—	—	—	—	—
Permlastic — Number present	18	18	18	18	18	18	18
Vel-Mix } Number duplicated	18	18	18	16	6	1	—
Duroc } Number duplicated	18	18	15	10	—	—	—
Castone } Number duplicated	18	18	18	10	2	—	—
Coe-Flex — Number present	18	18	18	18	18	18	18
Vel-Mix } Number duplicated	18	18	18	16	10	5	1
Duroc } Number duplicated	18	18	18	14	2	—	—
Castone } Number duplicated	18	18	15	7	1	—	—
Elasticon — Number present	18	18	18	18	18	18	17
Vel-Mix } Number duplicated	18	17	16	14	6	1	—
Duroc } Number duplicated	18	18	18	17	3	—	—
Castone } Number duplicated	18	18	16	7	—	—	—
Siligel† — Number present	18	18	18	18	18	18	18
Vel-Mix } Number duplicated	9	9	9	7	3	2	—
Duroc } Number duplicated	6	6	2	2	1	—	—
Castone } Number duplicated	13	12	9	4	1	—	—
Justi† — Number present	18	18	18	18	18	18	17
Vel-Mix } Number duplicated	9	9	9	9	6	2	—
Duroc } Number duplicated	9	8	7	3	—	—	—
Castone } Number duplicated	9	9	7	1	—	—	—

*The data show the number of indentations of each size present with each impression material and the corresponding reproduction in three stones.

†One series discarded because of poor surface. Satisfactory dies routinely secured only after the impression was allowed to stand overnight before pouring.

Laboratory 2, using its previously described method of evaluation, ran a series with similar combinations of materials. Six models were poured with each stone, making a possible total of eighteen for each size indentation if all were reproduced. The number of indentations of each size duplicated by both the impression material and the corresponding stone is listed (Table IV). The number of indentations reproduced in stone always decreased as the size of the indentation became less. The worst reproduction, both in number and quality of stone surface, was with alginate, while the polysulfide rubbers and silicones showed the best

reproduction. However, upon immediate pouring, the inferior surface with these batches of two of the silicones is a definite disadvantage.

The differences in the ability of the three stones to reproduce the indentations is summarized in Table V. The percentage of reproduction, calculated from the total number of indentations presented by all of the various impression materials, is shown. These data suggest some difference in the behavior of the different stones and indicate that all of those tested are incapable of repeatedly reproducing the finer detail of the impression. It is quite possible that particle size of the stone is a pertinent factor in failure to copy fine marginal detail.

TABLE V. PERCENTAGE OF REPRODUCED INDENTATIONS IN THREE STONES

STONE	INDENTATION NUMBER						
	1	2	3	4	5	6	7
Vel-Mix	74	69	60	45	23	9	1
Duroc	69	70	56	33	4	–	–
Castone	78	74	64	26	—	–	–

DISCUSSION

The general results obtained by the two separate laboratories were comparable, indicating that the test method developed is a satisfactory one for studying this problem. Even though the data were analyzed somewhat differently by each group, the trends were the same and the data complement each other.

In evaluating the clinical significance of the data, it is well to consider that the test indentations varied from 34 to 422μ. It has been stated that visual acuity under optimum conditions is approximately 50μ.[9] It thus appears that failure to reproduce the very fine indentations on this test die is of clinical significance since they lie close to, or above, visual detection. Furthermore, since every effort must be directed toward complete reproduction of dimension and detail, even differences between the materials which are not visible to the naked eye may be important.

This investigation did not include the effects of many variables which might influence surface detail, such as imbibition and syneresis of hydrocolloid and alginate, effect of surface-hardening agents used with the stones, setting expansion of the stones, fixing solutions with alginates,[8] etc. These phenomena need further study.

The greatest problem is the production of the cast once an impression is made. It can be seen that the gypsum-base cast materials are somewhat inferior in their ability to reproduce the finer details of an impression.

CONCLUSIONS

1. A difference can be demonstrated in the ability of various impression materials to reproduce fine surface detail. Polysulfide rubbers, hydrocolloid, and

silicone materials appear to be excellent, while alginates are definitely inferior both in their inherent behavior and in combination with the three die materials tested.

2. The ability of the impression material to register detail from the original die exceeded the reproduction capabilities of the gypsum cast materials tested.

3. A difference was noted in the behavior of the stones tested in regard to reproduction of small detail.

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ACCURACY OF IMPRESSIONS MADE WITH ELASTIC IMPRESSION MATERIALS

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THE NEW ELASTIC IMPRESSION MATERIALS—polysulfide rubber base, referred to commercially as Thiokol, and silicone—have been used with good clinical results for operative and fixed partial denture restorations. Laboratory studies attest to the accuracy of these materials for long-span impressions, and the literature indicates many techniques for their use in impressions of partially edentulous and edentulous arches. The purposes of this study were, first, to select a method of manipulation of Thiokol and silicone materials which would consistently record the dentition with accuracy for removable partial denture construction and, second, to compare the clinical accuracy of Thiokol and silicone materials with that of reversible and irreversible hydrocolloids and silver-plated Thiokol material.

METHOD AND PROCEDURES

A laboratory study was conducted to study techniques of manipulation and the working qualities of Thiokol and silicone materials. A partially edentulous, autopolymerized acrylic resin master model was made in a Columbia Dentoform rubber mold. Preparations made in the master model provided a means of orienting a gold casting on it and on casts made from impressions of this master model (Fig. 1). The fit of the casting on the master model was compared with the fit of the casting on casts made from the master model.

Thirty-five different casts were made from the master model by controlling some variables and altering others. The most consistently accurate results with both Thiokol and silicone materials were obtained with acrylic resin trays made with one thickness of baseplate wax as a spacer, loaded with a low viscosity material,[1] and used in combination with an injection technique. When acrylic resin trays were used, an adhesive was necessary unless the tray was generously perforated, but multiple perforations resulted in a considerable loss of material. The adhesive had to be painted on lightly and very well dried. If the adhesive pooled or was not thoroughly dried, inaccuracies resulted because the rubber material was not held in place in the tray. Modeling compound trays with a gauze liner or with adhesive usually produced inaccurate casts. The adhesive attacked the surface

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of the modeling compound, made it soft and tacky, and apparently did not afford a solid base for the rubber lining. A light-bodied wash in a more heavily bodied impression was not consistently accurate. Two material techniques, such as combining a heavier base material in the tray with a lighter material in the syringe, were accurate but very difficult for one person to mix and manipulate successfully.

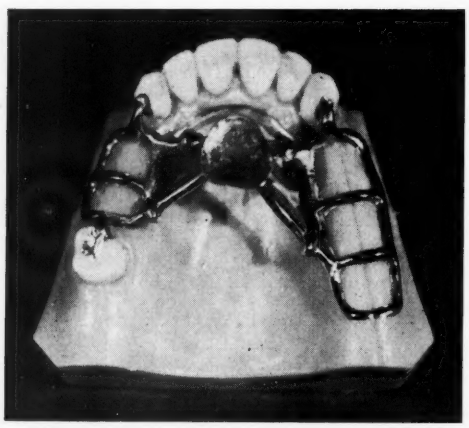

Fig. 1.—The acrylic resin master model with the gold casting in place. The fit of the casting on similar casts was used as a criterion for judging the accuracy of the impression.

Fig. 2.—The armamentarium necessary for a Thiokol impression includes a mixing pad and spatula, a rubber adhesive, a low viscosity Thiokol material, a syringe, a timer, and an acrylic resin tray made over a study cast.

At the conclusion of the laboratory study, a patient with a Class II (Kennedy), modification I, edentulous situation was used in a clinical study to compare the accuracy of reproduction of Thiokol, silicone, reversible hydrocolloid, irreversible hydrocolloid, and silver-plated Thiokol impressions. Three consecutive impressions with each of the five different types of materials produced 15 different casts. In addition casts were poured into the three Thiokol impressions immediately after the original casts were removed. Another Thiokol impression was allowed to bench-age 70 hours before pouring.

The Thiokol and silicone impression trays were made with autopolymerizing acrylic resin on a study cast which had a single layer of baseplate wax adapted over it. Three 2 by 2 mm. areas were cut from the wax spacer on divergent cusp tips. The tray was allowed to rest only on those areas and not at random, since the surfaces where the tray rested were usually distorted. Tray support of the

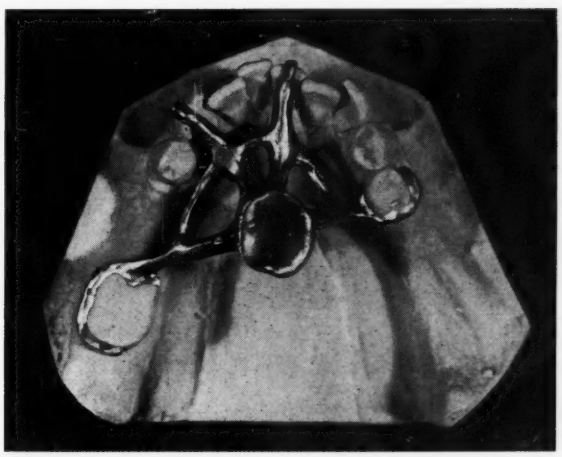

Fig. 3.—The casting which was used in the clinical study to compare tooth position in the mouth with the tooth position the various materials recorded is shown on a typical cast.

impression material was necessary for accuracy. A handle on the tray aided in the removal of the impression. It required 4 minutes to mix 6-inch strips of each of the base and accelerator of the Thiokol and silicone materials, load the syringe and tray, inject the material, and seat the tray (Fig. 2). The resulting impressions were allowed to remain in the mouth 10 minutes from the start of mixing, and were bench-aged 1 hour before pouring in improved stone or silver-plating.

Techniques which followed the manufacturers' directions were used for the reversible and irreversible hydrocolloid impressions. The three silver-plated casts were made from Thiokol impressions by painting them with a silver metalizing powder, immersing the impressions in a basic silver-plating solution, and plating at 0.1 ampere for 22 hours. The plating time used was more than is usually required for clinical impressions.

Two methods of analyzing these casts were employed. The first was an analysis of each cast across two arcs on a modified microcomparator,[2] utilizing

approximately 94 reading on each cast. Using this instrument the measuring error was only 0.001 inch. The second method used a casting that fit four widely spaced tooth surfaces (Fig. 3). All comparator readings were made before the casting was seated, to prevent any cast abrasion. The measurements on the comparator yielded statistically valid data for a particular series of casts and data for a comparison of different impression materials (Table I).

RESULTS OF CLINICAL STUDY AND DISCUSSION

Casts From Thiokol Impressions.—These gave the most consistent results. The casting fit the three casts equally well. Cast surfaces were dense and smooth and fine detail was generally reproduced.

Casts From Silicone Impressions.—These were consistent, although they would not have been acceptable for clinical use because the material did not flow together evenly, and surface irregularities resulted. Lowering the viscosity of the material

TABLE I. SUMMARY OF MICROCOMPARATOR DATA

CASTS ANALYZED	NUMBER OF READINGS	AVERAGE DEVIATION (INCHES)	STANDARD DEVIATION (INCHES)
Original cast, same areas, no remounting	282	.001	.0014
Original cast remounted three times	282	.001	.0014
Three Thiokol casts	291	.0013	.0019
Three silicone casts	282	.0014	.0018
Three silver-plated Thiokol casts	273	.0015	.0020
Three reversible hydrocolloid casts	285	.0018	.0024
Three irreversible hydrocolloid casts	282	.0025	.0036
Three second casts in the Thiokol impressions	282	.0019	.0025
Thiokol impression poured after 70 hours on the bench, compared with average of the Thiokol casts	96	.0027	.0035

nearer the viscosity of the more lightly bodied Thiokol materials should eliminate this problem. The casting fit the casts equally well and the cast surface was smooth and dense, although fine details were not consistently reproduced.

Casts From Silver-plated Thiokol Impressions.—These showed an insignificantly increased deviation from Thiokol impression casts. Since Thiokol can be silver-plated without significant distortion, it possesses an advantage over other elastic materials because the surface toughness of the silver-plated cast is greatly increased over stone. The casting fit less well on the silver-plated casts than on the Thiokol impression casts. This could have been due to the greater surface toughness of the silver-plated casts resisting abrasion when the casting was seated. Surface detail was better than on stone casts.

Casts From Reversible Hydrocolloid Impressions.—These showed an insignificantly increased deviation from Thiokol impression casts. The casting fit the casts well and the surface was dense and generally smooth, with fine detail reproduced.

Casts From Irreversible Hydrocolloid Impressions.—These showed a significant deviation in their consistency of reproduction. The casting did not fit the three casts as well as it fit the Thiokol casts. The surface of the casts was pitted with fine bubbles.

Second Casts From Thiokol Impressions.—These were distorted slightly from the original cast, but as a group they seemed to deviate similarly, since the different casts possessed a statistically insignificant average deviation. Similar stretching and pulling of the material from the tray during removal from the original cast is a logical explanation. The casting did not fit these casts as well as it fit the original casts, but stone surfaces and detail reproduction were similar to the original casts.

Cast Poured in Thiokol Impression After 3 Days of Bench-Aging.—This deviated significantly from the casts poured after 1 hour. There were gross discrepancies in the casting fit, but the surface of the cast was dense and smooth.

SUMMARY

The Thiokol and silicone impression materials were investigated in a laboratory study to determine their best means of application to removable partial denture impressions. Several methods were evaluated and a technique which produced reliable, consistent results was evolved. A clinical situation was selected and casts made with Thiokol and silicone material were compared with irreversible hydrocolloid, reversible hydrocolloid, and silver-plated Thiokol casts. The reproducibility of casts from each impression material was statistically compared using data obtained on the microcomparator. By means of graphs of this data the models were compared with each other. All of the casts were compared with a casting which fit the mouth.

CONCLUSIONS

1. The Thiokol materials, when manipulated as suggested, will produce impressions of a complete dental arch as accurately as any other elastic impression material. The technique of use is not complicated, and it does not require expensive equipment.
2. Silver-plating Thiokol impressions does not significantly reduce their accuracy, and the cast produced is much tougher than stone and has finer detail.
3. Thiokol impressions, silver-plated Thiokol impressions, and reversible hydrocolloid impressions produce casts which are reliable and accurate.
4. The silicone materials were accurate and consistent, but surface irregularities occurred frequently.
5. Reproduction of the shape of the mouth with irreversible hydrocolloids was not consistent.
6. Lengthy delays before pouring Thiokol impressions will result in inaccurate casts, because the material will shrink.
7. Second casts made in Thiokol impressions are not as accurate as the original casts.

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521 North Eleventh St.
Richmond, Va.

MIXING THIOKOL RUBBER IMPRESSION MATERIALS

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A large glass slab makes the best base for mixing Thiokol rubber for impressions. A slab about 8 inches square allows room enough to "iron out" the material for the ideal mix.

A stainless steel table knife, preferably with a slightly rounded blade, is superior to a spatula for mixing this material. If the blade is dipped into the (brown) catalyst first, the mixing will be easier. The working time can be increased slightly by chilling the slab; it can be decreased slightly by warming the slab.

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MISCELLANEOUS

SAFETY FEATURES OF DENTAL X-RAY MACHINES

W. W. WAINWRIGHT, D.D.S.

Canoga Park, Calif.

A LEAD DIAPHRAGM and an aluminum filter should be used as safety features in every dental x-ray unit.[1] Through these means, the radiation exposure to the patient can be reduced as much as 60 per cent. The radiation exposure to office personnel where screens are not used is similarly reduced. The most important single factor in x-ray safety, however, is the use of the new, ultra-fast emulsions.[2] Changing from slow-speed film to ultra-fast film reduces radiation exposure by over 90 per cent.

The lead diaphragm and aluminum filter are the two most important safety features of dental x-ray units introduced since the beginning of 1957. These features can be added to earlier model x-ray units if the units have metal housing around the x-ray tube. Any dental x-ray unit in which the glass of the tube can be seen from the outside should be destroyed. These units should not be modernized or turned in for credit on a new unit, because the old unit may be placed on the market for resale. It is necessary that roentgen exposures be reduced, because of the changing events of the atomic era.

LEAD DIAPHRAGM AND ALUMINUM FILTER CONSTRUCTION

A universal chart for determining the dimensions of the lead diaphragm and aluminum filter for installation in earlier types of dental x-ray machines is seen in Figs. 1 and 2. The materials needed for the diaphragm and filter are a 1/16-inch thick lead sheet, approximately 4 by 4 inches, and an aluminum sheet (technically pure: 1,100), approximately 4 inches by 4 inches by 1.5 mm. in thickness (0.060 inch or 3 sheets 0.020 inch). The lead and aluminum can be obtained from a plumber, metal supplier, dental supply distributor, or dental society.

PROCEDURE FOR INSTALLATION

The "target-skin" distance must be obtained from the manufacturer of the x-ray unit. If the measurement is given as the "target-film" distance, 1 inch must be subtracted in order to use the accompanying illustrations.

Read before the American Academy of Restorative Dentistry, Chicago, Ill.

Fig. 1

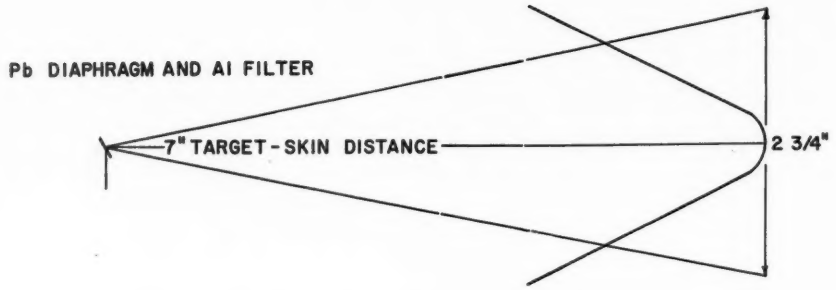


Fig. 2

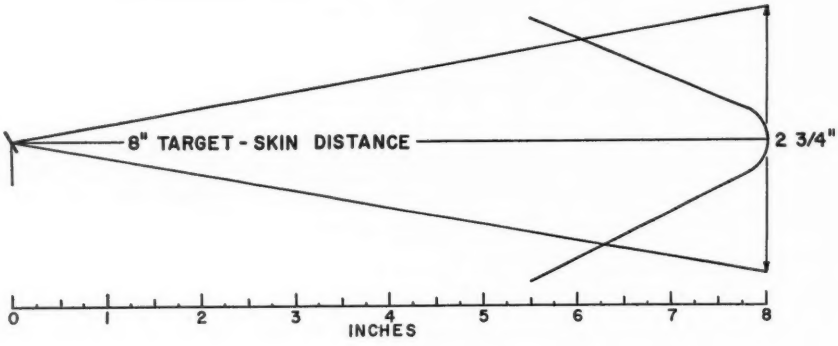


Fig. 3

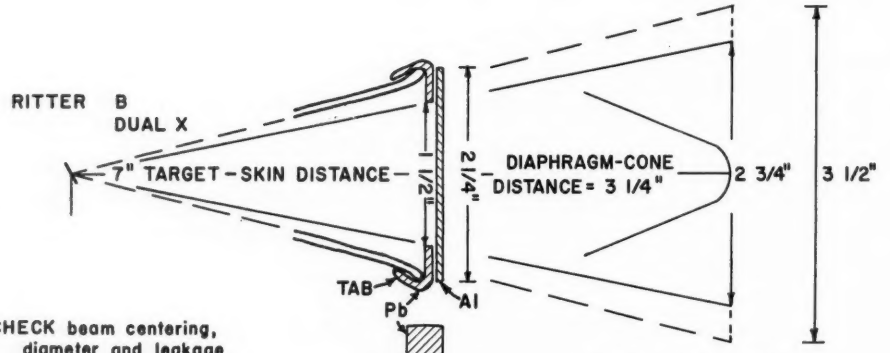
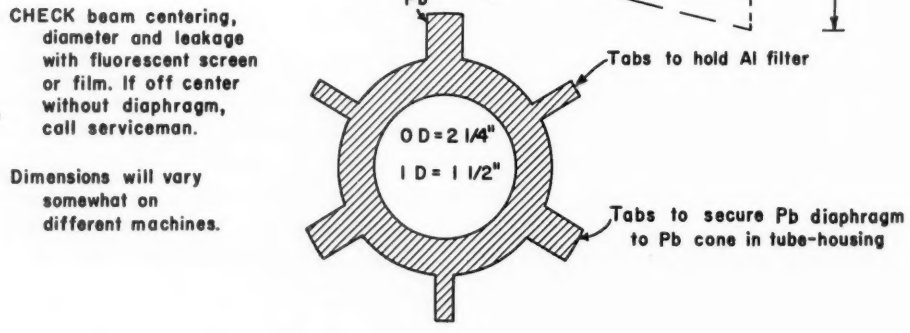


Fig. 4


CHECK beam centering, diameter and leakage with fluorescent screen or film. If off center without diaphragm, call serviceman.
Dimensions will vary somewhat on different machines.
Tabs to hold Al filter
O D = 2 1/4"
I D = 1 1/2"
Tabs to secure Pb diaphragm to Pb cone in tube-housing

Figs. 1 and 2.—The dimensions for the lead diaphragm and aluminum filter may be obtained from these charts.

Fig. 3.—The dimensions of the lead diaphragm and aluminum filter for the Ritter B and Dual-X units may be obtained from this chart.

Fig. 4.—A lead diaphragm for Ritter B and Dual-X units.

The diameter of the seat which will contain the lead diaphragm and aluminum filter is measured. This measurement indicates the outer diameter of the diaphragm and filter.

The distance from the seat for the diaphragm to the tip of the cone is determined. This distance, measuring from the right side at the tip of the cone back to the position of the diaphragm, is marked on the chart for the unit (Fig. 1 or 2). At this point a vertical line is drawn, and the distance on this line between the two divergent lines determines the diameter of the hole in the lead diaphragm. This diameter gives a beam measuring 2¾ inches in diameter at the tip of the cone.

The lead diaphragm and aluminum filter are now cut and installed; afterward the beam must be checked for centering. The diameter of the beam and leakage are checked with a fluorescent screen or with a large-sized film such as is used in extraoral roentgenography. If the beam is "off center" without the diaphragm, call the service man and have him adjust the unit. The adjustment should not be made by installing an "off-center" lead diaphragm.

The chart to determine the size of the lead diaphragm and aluminum filter for the Ritter B and Dual-X units is seen in Fig. 3. These units have a 7-inch target-skin distance and, without the lead diaphragm, deliver a beam 3½ inches in diameter. The beam can be reduced to 2¾ inches in diameter at the tip of the cone by installing the lead diaphragm illustrated in Fig. 4. The diaphragm is installed by folding the tabs over the lead cone in the unit. Since there is a slight difference in dimensions from one unit to another, beam centering, beam diameter, and leakage *must* be checked with a fluorescent screen.

EXPOSURE REDUCTION

The simple change of beam diameter from 3½ inches to 2¾ inches results in a 38 per cent reduction of area exposed on the patient. In some units, if the lead diaphragm is removed it is possible to deliver a beam as large as 6 inches in diameter to the skin of the patient. Every dentist should remove the cone from his tube periodically to make certain that the lead diaphragm is properly installed and of the proper size. A beam 2¾ inches in diameter at the tip of the cone enlarges to approximately 3 inches in diameter at the plane of the film, and this covers ample area to avoid cone-cutting.[3]

The recommended thickness of added aluminum filtration is 1.5 mm. because of the state law in New York. However, there is evidence that 1.0 mm. of additional aluminum filtration is probably optimum for the best diagnostic quality and exposure time.[4] Exposure times must be almost doubled after 1.5 mm. of aluminum filtration is added.

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8441 Yukon Trail
Canoga Park, Calif.

BOXING AND CAST POURING

LaMar W. Harris, D.D.S.
Chicago, Ill.

Complaster* (plaster of Paris and cornstarch) offers an ideal means of "boxing" Thiokol or other types of impressions of complete or partial cast size.

The impression may be seated lightly into a nest of Complaster mixed just thick enough to have a puttylike consistency. The Complaster can be gently guided to the border of the impression, so a perfect outline will remain. The matrix will be set and ready to trim in a matter of minutes. Then, boxing wax may be used to surround the entire impression.

A separating medium is applied to the Complaster, and the cast can be poured. A split-remounting plate can be added by having its arm held steady in position by the boxing wax.

The Complaster will literally fall away when the boxing wax is removed and after the cast and impression are placed in warm water. A knife blade is drawn in a triangular pattern through the Complaster to loosen it. Very little trimming on the finished cast will be necessary.

25 East Washington St.
Chicago 2, Ill.

*The William Getz Corporation, Chicago, Ill.

SOME COMMENTS ON PROSTHETIC LITERATURE

ROBERT G. VIG, D.D.S.*
Inglewood, Calif.

INTERSPERSED AMONG the very well-written and informative articles in prosthetic literature are those whose contents seem open to criticism of various kinds. If valid, these criticisms can be applied equally well to literature concerning other branches of dentistry and possibly to medical publications generally. For all I know, professions outside the field may be plagued by the indentical weaknesses that are present in prosthodontic publications. Since this article represents only the opinion of one man, and he a noncontributor previous to this sally, it is likely of little value and can be disregarded by those who feel that the science of dentistry is best served by treating it only with kindness and respect. At any rate, the personal evaluation of another's opinion is generally in direct proportion to the extent to which he is in agreement with one's own.

Since the criticisms contained here will be couched in general terms, they will likely not be offensive to anyone for the simple reason that no one will recognize the description of himself or his work. He obviously could not see it in the same light, otherwise he would never have submitted his manuscript for publication. For instance, if any author were to be told that some of our articles are completely without new information or new techniques and are not even a good literature review, that these articles seem to have been published largely to fill space and perhaps contribute to the personal aggrandizement of the author, he would not for a minute believe it to be so, though his works fulfilled those specifications exactly.

Since we can freely categorize the literature with no danger of incurring the indignation of its creators, we can proceed with impunity. Editors are a marvelously tolerant lot, as evidenced by some of their selections, and most members of the profession are so buffeted about between the legions of theories and their proponents that they are in no condition to resist another opinion.

Errors in literature twice jeopardize. They originally misinform, then, by constantly being referred to, gain a position of respect to which they are not entitled. They then themselves father a generation of erroneous conclusions by acting as a premise to which is joined another premise and presto—a faulty new conclusion is born. If we cannot avoid confusion, let us at least try to eliminate a needless amount. That is to say, we are not recommending confusion as an essential ingredient, merely recognizing its inevitable presence.

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IDEAS OR FACTS?

Ideas presented will not be equally meritorious since we possess unequal abilities. Almost any idea is good, even when it is all wrong, since it does engender discussion. Hence, it stimulates new ideas which may contain points of value. They must be labeled as ideas, thoughts, or theories, however, not facts or bits of scientific information. In this lies a weakness which we should attempt to eradicate. If ideas and facts become so labeled and isolated, how much more credence can be placed in prosthodontic literature.

An insidious entry in the field of dental authors is the man who says nothing, but says it so obscurely that it is thought to be profound since it cannot be understood. This type of creation is praised and held in high regard until someone whose opinion is unassailable harpoons it sharply. Then everyone wonders why it has been so universally admired. This phenomenon is the stock in trade of charlatans, but in our special case it may be more kindly ascribed to a misguided effort.

IDEAS OF SMALL VALUE

Then there are those who seize upon an idea of small value and spend the rest of their lives and many pages in books and magazines defending it. This constant attention to a small matter tends to magnify its importance by sheer volume and endows its creator with an air of authority on other subjects, about which he knows or cares little except as to how they affect his minimus offspring.

INCORRECT CONCEPTS

Some of our early leaders who formulated concepts founded on information later discredited so impressed their followers that they continue to cry their wares though they have long since been proved incorrect. This does not confuse the men who survived the original onslaught, and whose concepts are in tune with the knowledge of the present day. It does, however, tend to bewilder the reader who does not understand the historical significance of the situation and thinks that a new thought is being presented. If the words, "Danger, This Material Is Obsolete," could be stamped on articles answering this description, no one would then be harmed and the author would still have the feeling that his philosophy was being immortalized.

INADEQUATE RESEARCH

One of the most quoted articles in recent years was done with a great deal less research than accuracy or prudence would dictate. The section describing the experiments, leading to conclusions which were profoundly radical, was misleading. Somehow, it gave the idea that a large number of cases had been analyzed, which was not correct. On the basis of this work, a new concept was founded and led by some of the ablest of our clinicians. This clarion call held particular appeal to them, since it seemed to affirm their previously unsupported opinions. The mere fact that other investigators have since discredited the principal conclusion has in no way affected the number of references to it in the literature. Had the extent of

the experimental material been clearly stated and the article labeled a preliminary report, this tragedy would never have occurred. The conclusion is now so firmly entrenched as a "fact" that its label being changed to "fancy" is very unlikely.

SCIENTIFIC OR UNSCIENTIFIC?

The word "scientific" holds a peculiar fascination to some authors. It crops up frequently in their writings. It seems to apply most aptly to the technique or opinion which they are presenting, in sharp distinction to the "unscientific" methods of those holding contrary views. By way of illustration, we may read statements such as, "It follows natural laws," or, "It follows physical laws," with no such laws quoted. Most of us are not sufficiently conversant with either natural or physical laws per se to confirm or deny their applicability, but our suspicion is aroused by such glib references without adequate definition. A firm belief in the truth and accuracy of a thing does not make it scientific. If the word were used less loosely, its value would increase greatly.

UNRELATED REFERENCES

Occasionally one encounters an article which is followed by a forbidding list of references. The pages are sprinkled with reference numbers, but the information so presented has little coherence or originality. The impression is somehow created that these rather unrelated references are a product of familiarity without understanding. Certainly a large reference list is not to be decried, rather commended; but the quotations should mean something explicit and should not be inserted merely to display acquaintance with the literature.

REDEFINITION

Men of ideas whose varying backgrounds tend to create shades of opinion on every conceivable subject can scarcely be expected to agree on definitions. We in prosthodontics can be eternally grateful for the *Glossary of Prosthodontic Terms* compiled by the Academy of Denture Prosthetics. It can be used authoritatively. It represents a common meeting ground of some of the finest minds in the profession. Why then do some eminent authors insist on redefining our accepted terminology? This redefinition is actually being advanced to "put an end to the confusion." "Whose confusion?" we might ask. Creation of a semantic jungle into which we advance at our own peril surely does nothing to further our understanding. Meanings of words do tend to change with the passage of time, but surely we can let the ink dry on our *Glossary* before launching a pell-mell attack upon it.

CONCLUSIONS

To those possessed of greater tolerance than mine, this indictment of prosthodontic literature may seem harsh and purposeless. Others may feel that the criticisms were not severe enough. The mere fact that shades of opinion, ranging

from extreme opposites to perfect agreement, are held on most subjects in prosthetic dentistry is testimony of its controversial nature. It also demonstrates the fact often observed that our varied backgrounds and mental processes cause us to see things in different lights. At least we can agree that self-criticism, properly directed, can be valuable and lead to constructive changes.

Happily, these remarks apply to a mere fraction of the corpus literati. The remainder represents the sincere efforts of dedicated men whose wisdom can thus be shared through the medium of publication. To them, we extend our gratitude.

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ERRATUM

An error occurred in the article, "Complete Dentures and Transographics," by Mortimer C. Davis, D.D.S., Jersey City, N. J., which appeared in the January-February, 1960, issue of the Journal. The second and third sentences of the second paragraph on page 64 should have read: "For saliva removal, the patient is given premedication of 1/150 grain of Atropine Sulphate or 15 mg. of Pro-Banthine every hour beginning 3 hours before the office visit, then the fourth is given if needed."

NEWS AND NOTES

MEETINGS

Southeastern Academy of Prosthodontics, Monteleone Hotel, New Orleans, La., April 29 to May 1, 1960.

American Association for Cleft Palate Rehabilitation, Brown Palace Hotel, Denver, Colo., May 12 to 14, 1960. For further information write to Dr. D. C. Spriestersbach, Department of Otolaryngology, University Hospitals, Iowa City, Iowa.

Academy of Denture Prosthetics, La Concha Hotel, San Juan, Puerto Rico, June 19 to 24, 1960.

American Dental Society of Europe, Edinburgh, Scotland, July 5 to 8, 1960.

Indonesian Dental Association, Bandung, Indonesia, during July, 1960. For further information write to Dr. R. M. Soelarko, Congress Secretary, Indonesian Dental Association, 55 Riau-street, Bandung, Indonesia.

Swedish Dental Society, Centennial Meeting, Stockholm's Concert Hall and Apollonia, Stockholm, Sweden, Aug. 17 to 20, 1960. For further information write to Torsten Telander, Secretary, Swedish Dental Society, Nybrogatan 53, Stockholm Ö, Sweden.

The Fourth National Cancer Conference sponsored by the American Cancer Society, National Cancer Institute, will be held in Minneapolis, Sept. 13 to 15, 1960. The theme of the Conference is "Changing Concepts Concerning Cancer." For further information write to the American Cancer Society, Inc., Medical Affairs Dept., 521 West 57th St., New York 19, N. Y.

Canadian Dental Association, Ottawa, Canada, Sept. 25 to 28, 1960.

American Society of Oral Surgeons, Westward Ho Hotel, Phoenix, Ariz., Oct. 12 to 15, 1960. For further information write to Mr. D. C. Trexler, Executive Secretary, 840 North Lake Shore Dr., Chicago 11, Ill.

ANNOUNCEMENTS

Dentists from the States of Washington, Oregon, California, Montana, Nevada, Idaho, Utah, Arizona, Alaska, and Hawaii and from the Canadian Provinces of Alberta and British Columbia are invited to attend the Eleventh Triennial Pacific Coast Dental Conference in Portland, Ore., July 10 to 14, 1960. Dentists in other parts of the country planning to be in the Northwest during this period and wishing to attend this conference may obtain further information and application for registration from Dr. Kenneth R. Jensen, 1033 Southwest Yamhill St., Portland 5, Ore.

Reprints of the *Glossary of Prosthodontic Terms* may be obtained by writing to Glossary Reprints, 3939 Old Brownsboro Rd., Louisville 7, Ky. The price is fifty cents per copy, with a 20 per cent discount allowed on purchases of 20 or more copies. Cash, check, or purchase order *must* accompany the order.

An Oren A. Oliver Appreciation Banquet is being planned by the Tennessee State Dental Association for Sunday evening, May 1, 1960, at 6:30 P.M., Hotel Peabody, Memphis, Tenn. For further information, write to Dr. Lloyd C. Templeton, President, Tennessee State Dental Association, 1112 Exchange Bldg., Memphis 3, Tenn.

Reprints of *Principles, Concepts, and Practices in Prosthodontics* may be obtained by writing Dr. W. Les Warburton, Secretary-Treasurer, Academy of Denture Prosthetics, 807 Medical Arts Bldg., Salt Lake City 11, Utah. The price is twenty-five cents per copy, with a 20 per cent discount allowed on purchases of 20 or more copies. Cash, check, or purchase order *must* accompany the order.

By action of the Executive Council of the American Denture Society on Feb. 5, 1959, the Essay Contest for Senior Dental Students will not be held this year.

The American Equilibration Society has issued a leaflet entitled "Treatment for Returning the Lower Jaw to a Condition of Equilibrium." This leaflet explains to the patient, in simple terms, how stress in the temporomandibular joint can cause such troubles as headache, facial pains, dizziness, deafness, nervousness, and others, and how the stress can be removed by means of changing the occlusion of the teeth.

Any dentist or physician may obtain a copy of the leaflet by writing to the Secretary of the Society, Dr. Raymond C. Van Dam, 11431 South Halsted St., Chicago, 28, Ill.

"Artificial Dentures—A Health Service or a Health Hazard" is the title of a new leaflet published by the American Dental Assoication, Bureau of Dental Health Education. The leaflet explains to the public that artificial dentures can be a health service for those who have the advantage of professional attention from a dentist, or a health hazard for those who attempt to get denture services from nonprofessional sources. The leaflet discusses the education of a dentist and, in some detail, the many factors he takes into consideration in preparing dentures for a patient. It points out that those persons other than dentists who make dentures directly for the public are unqualified and probably are operating in violation of state laws regulating the practice of dentistry.

The leaflet is available from the Order Department, American Dental Association, 222 East Superior St., Chicago 11, Ill., at the following prices: 25 for $.75, 50 for $1.40, 100 for $2.25, 500 for $10.00. The Order Department will give price quotations for larger quantities on request.

A new Trubyte Work Authorization Program was announced to all dental laboratories in the United States during October, 1959. Trubyte's new work authorization forms are based upon a national survey made during the past 3 years to determine ways and means of providing the dental profession and the dental laboratory industry with a work authorization form which would meet the requirements of the various State Dental Practice Acts.

The increasing importance of the work authorization form and the necessity for providing accurate written information are emphasized by the fact that it is estimated there are now 25,000 dental laboratory technicians employed in the dental industry and approximately 70 per cent of all dental laboratory work is being performed by commercial dental laboratories. As a result, the relationship between the dentist and his dental laboratory is one which has received increasing attention on the part of organized dentistry, the organized dental laboratory industry, and the state regulatory agencies.

One of the most important day-to-day aspects of this relationship is in the work authorization form provided by the dentist to the dental laboratory as instructions for work or services to be performed. During recent years, new legislation regarding work authorizations has been introduced and existing regulations have been changed in many of the states. The laws of at least thirty states currently require use of written instructions in transactions between dentists and dental laboratories. In many states the requirement for an original form to be sent to the dental laboratory and a duplicate form to be retained in the dentist's office is being enforced. It can be expected that this requirement will be in effect in additional states in the very near

future. Furthermore, the American Dental Association is on record with a policy which recommends that each State Dental Practice Act require a written authorization for dental laboratory services.

From the findings of the Trubyte survey, an entirely new type of work authorization was developed. It became apparent that two different forms were desirable, one which would provide the dental laboratory with complete information for the construction of complete dentures and a second format for partial dentures, fixed and removable bridgework, crowns, and individual restorations.

Not only was the required information on the work authorization forms carefully considered, but also size and the manner of use were thoroughly investigated. Experience shows that a form which is printed on both the front and reverse sides is unsatisfactory, since fill-in of additional information on the reverse side makes the writing of the authorization unnecessarily complicated. More often than not, it was never used. The new forms meet this objection and provide complete space on the front for detailed instructions.

The requirement for an original form to be sent to the dental laboratory and a duplicate to be retained in the dental office was also carefully evaluated. The new format simplifies this by furnishing an original white copy, which is perforated and may be readily torn out, and a yellow carbon copy which remains permanently bound in the work authorization pad. The size of this form was also carefully considered so that it would fit the standard size dental laboratory work tray. The flat page size of the form is 7½ by 8½ inches, and when received by the laboratory it may be folded down the middle to 4¼ by 7½ inches and placed in the work tray.

The difficulty of developing a single work authorization form which complies with not only the letter but the spirit of all the State Dental Practice Acts should be readily apparent. Insofar as it is now possible to so state, however, the new Trubyte Work Authorization Forms are in general compliance with the laws of at least the majority of the states. Corrections or changes may become necessary in the future, but at the present time this new format will be satisfactory for use in the majority of the states.

This new Trubyte service is offered to dental laboratories at the actual production cost of printing, plus postage or shipping charges.

The University of Alabama School of Dentistry will present a refresher course in Complete Denture Prosthesis by Dr. William L. McCracken on March 4 to 6, 1960.

Full details regarding this program may be obtained by writing The Director, Refresher Course Program, University of Alabama School of Dentistry, 1919 Seventh Ave. South, Birmingham, Ala.

Boston University, School of Medicine, Division of Graduate Studies, Department of Stomatology, announces the following postgraduate courses:

Periodontal Therapy, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, Dr. Gerald M. Kramer, Dr. William Pendergast, Dr. Jack Bloom, and Associates, April 4 to 9, 1960.

Apicoectomy-Surgical Endodontic Procedures, Dr. Herbert Schilder and Dr. Leonard Parris, April 18 to 22, 1960.

Periodontal Pathology, Dr. Henry M. Goldman and Dr. Jack Bloom, April 25 to 30, 1960.

Pulp Protection in Operative Dentistry, Dr. Harold Berk, May 12 to 14, 1960.

Periodontal Prosthesis, Dr. Leo Talkov, Dr. David J. Baraban, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, and Dr. Gerald M. Kramer, May 16 to 20, 1960.

Surgical Procedures in Periodontal Therapy, Dr. Lewis Fox and Associates, May 23 to 27, 1960.

For further information write to Director of Postgraduate Studies, Department of Stomatology, Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.

Boston University, School of Medicine, offers 1-year courses in Oral Surgery and Endodontics and courses of 2 academic years in Orthodontics and Prosthodontics.

For further information concerning these courses write to Department of Stomatology, Boston University, School of Medicine, 80 East Concord St., Boston 18, Mass.

Indiana University, School of Dentistry announces the following postgraduate courses:

Crown and Bridge, April 11 to 14, 1960.

Complete Denture Construction, June 15, 22, and 29, July 6 and 13, 1960.

Partial Denture Design and Construction, July 11 to 14 and on four consecutive Thursdays, June 23 and 30, July 7 and 14, 1960.

Course for Laboratory Technicians on Partial Denture Design and Construction, July 25 to 28, 1960.

For further information and application write to Indiana University, School of Dentistry, 1121 West Michigan St., Indianapolis 2, Ind.

The Lancaster Cleft Palate Clinic offers a seminar on April 4 to 7 in diagnosis, research, and treatment of individuals with oral-facial-speech handicaps.

For further information write to Dr. M. Mazaheri, Chief—Dental Services, Lancaster Cleft Palate Clinic, 24 North Lime St., Lancaster, Pa.

The Loyola University, School of Dentistry, announces the following postgraduate courses:

Diagnosis, April 4 to 6, 1960.

Principles of Occlusion and Articulation (part III), April 12 and 13, 1960.

Differential Diagnosis of Oral Lesions, April 20 to 22, 1960.

For further information and application write to Director, Postgraduate Division, Loyola University, School of Dentistry, 1757 West Harrison St., Chicago 12, Ill.

Northwestern University Dental School announces the following postgraduate courses:

Major Oral Surgery—B, April 4 to 8, 1960.

Maxillofacial Prosthesis, April 4 to 6, 1960.

A Practical Approach to the Use of Gold Foil, April 4 and 5, 1960.

Procedures in Dental Prosthetics as Related to Physiologic Function, April 20 to 22, 1960.

Diagnosis, Roentgenography and Treatment Planning, April 27 and 28, 1960.

Edmund Noyes Memorial Lecture, May 4, 1960.

The Use of Drugs in Dental Practice, May 9 to 11, 1960.

Prosthetic and Orthodontic Rehabilitation for the Cleft Palate Patient, May 9 and 10, 1960.

Conference for Teachers of Pedodontics, June 6 and 7, 1960.

For further information and application write to Northwestern University Dental School, 311 East Chicago Ave., Chicago 11, Ill.

The Ohio State University, College of Dentistry, announces the following postgraduate courses:

General Anesthesia, April 4 to 8, 1960.

Oral Surgery, April 11 to 15, 1960.

Clinical Periodontics, April 11 to 15, 1960.

Post-College Assembly, April 20 and 21, 1960.

Partial Denture Prosthodontics, May 2 to 6, 1960.

Complete Denture Prosthodontics, May 9 to 13, 1960.

Dental Drugs in Action, May 19 and 20, 1960.

For further information and application write to Postgraduate Division, College of Dentistry, The Ohio State University, 305 West Twelfth Ave., Columbus 10, Ohio.

The Ohio State University, College of Dentistry, announces that it is receiving applications of students for the Curriculum of Dental Laboratory Technology. This course of study of the laboratory phases of prosthodontics extends over 2 academic years and leads to a Certificate of Graduate Dental Laboratory Technologist.

Application forms may be obtained by writing to the Entrance Board, the Ohio State University, Administration Bldg., 190 North Oval Dr., Columbus 10, Ohio. Applications should be received by the Entrance Board by Aug. 1, 1960, for admission to the class starting Sept. 26, 1960.

For further information write to the Chairman of Dental Laboratory Technology, The Ohio State University, College of Dentistry, 305 West Twelfth Ave., Columbus 10, Ohio.

The University of Pennsylvania, School of Dentistry, announces the following postgraduate courses:

Extra-oral Tracers in Rehabilitation of Function, March 21 to 23, 1960.

Pulp Reactions to Operative Procedures, March 25 and 26, 1960.

Complete Denture Prosthesis, March 28 to 31, 1960.

Endodontics, March 28 to April 8, 1960.

Applied Anatomy, April 20 to 22, 1960.

For further information and application write to Director of Postgraduate Courses, University of Pennsylvania, School of Dentistry, 4001 Spruce St., Philadelphia 4, Pa.

The University of Pittsburgh, School of Dentistry, Division of Graduate Education, is accepting applications for graduate study in the fields of Anesthesiology, Oral Surgery, Orthodontics, and Prosthodontics leading to the Master of Science degree. Selection of students for the fall session of 1960 will be made in April, 1960.

A nondegree, full-time 12-month course in General Anesthesia is also available for qualified dental graduates.

For further information and application forms write to Director of Graduate Education, University of Pittsburgh School of Dentistry, Pittsburgh 13, Pa.

Temple University School of Dentistry announces the following postgraduate courses:

Advanced Surgical Techniques in Periodontal Therapy, April 4 to 9, 1960.

Graduate Orthodontics, Sept. 12, 1960, a 2-year course.

For further information and application write to Dr. Louis Herman, Director of Postgraduate Studies, Temple University School of Dentistry, 3223 North Broad St., Philadelphia 40, Pa.

Tufts University School of Dental Medicine announces the following postgraduate courses:

Advanced Surgical Periodontal Treatment Techniques, April 4 to 6, 1960.

A Special Participation Course in Periodontology, April 25 to 29, 1960.

Special Postgraduate Refresher Course in Prosthetics for the Periodontal Patient, May 9 to 12, 1960.

A Special Postgraduate Refresher Course in the Diagnosis and Treatment of Pain and Other Symptoms Arising from Temporomandibular Joint Disturbances, May 24 and 25, 1960.

Complete Denture Prosthesis, June 6 to 10, 1960.

Applications are now being accepted for two Research Fellowships in Oral Pathology and Periodontology for the school year beginning September, 1960.

For further information and application write to Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

Western Reserve University, School of Dentistry, announces the following postgraduate courses:

Oral Rehabilitation Using the P-M Instrument Technique, April 1 and 2, 1960.

Psychodynamics and Practice Administration, April 23 to 25, 1960.

Periodontics, June 2 to 4, 1960.

For further information and application write to Director of Postgraduate Education, School of Dentistry, Western Reserve University, 2165 Adelbert Rd., Cleveland 6, Ohio.

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